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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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NOTICE.

LAHORE WATER WORKS EXTENSION.

CONTRACT No. 1.

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Tenders for Supplying, Erecting and RUNNING

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(Signed) H. P. TOLLINTON,
President.
Municipal Committee,
Town Hall, Lahore. R 756

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The Appointment is in the Indian Educational Service, and carries a salary of Rs. 750 a month, rising by annual increments of Rs. 50 to Rs. 1000 a month. Free bachelor quarters will be provided. The professor will be expected to take part in the ordinary social work of a residential college.

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Applications should be sent at once in covers marked "C.A." to the SECRETARY, BOARD OF EDUCATION, Victoria and Albert Museum, London, S.W. 7. Scottish candidates should apply to the Secretary, Scotch Education Department, Whitehall, London, S.W. 1. R 350

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Engineer's Office,
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7th January, 1919. R 813

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WANTED, used to small electrical work. Must be careful and painstaking and have had experience on similar class of work. London District.—Address, stating age, salary and experience to R 776, Offices of ENGINEERING.

THE CALORIMETRY OF COAL.

THE selection of a coal best adapted for industrial purposes depends on so many factors that it is perhaps impossible to devise a test, or a series of tests, on which absolute reliance can be placed. A thermometric test is, however, entitled to some confidence, for it does provide precise knowledge of certain qualities, and trustworthy laboratory experiments directed to this end have a definite value. Other factors as specific gravity, quantity and character of the ash, &c., enter into the problem of coal evaluation, and may have equal or greater importance according to the equipment and the character of the heating required, but the calorific value has generally the highest claim to consideration, irrespective of the proposed use of the coal. The increasing frequency with which the combustion test appears in specifications is an indication of its growing favour, and it is significant that the American Government recognising the supreme importance of this one factor, is now purchasing the greater part of its fuel supply based on heating value alone. The United States Bureau of Mines testing department, where some 90 to 100 calorific determinations are made daily, has found the demands so great that it has had under consideration the adoption of apparatus that shall facilitate the process of examination, reduce the amount of skilled labour required, and above all things ensure accuracy and reliable service. The results of their experience are expressed in a report* that is particularly interesting on two grounds. It shows and describes the mechanical arrangement that has been found the most satisfactory after trial and experiment, and it exhibits the reduction of the observations, discussing the sources of error, the mechanical devices that tend to eliminate those errors, and when these are not sufficient, the arithmetical corrections that are necessary for the utmost accuracy.

At the outset a plea for greater accuracy is urged. Such a plea is not unnecessary, for it is frequently urged that the selection of samples is attended with so much uncertainty and is accompanied by such a high percentage of error, that precision is necessarily excluded from the problem. With this disparaging assertion the authors disagree, and their position will be generally sustained. It is argued that a high degree of accuracy is necessary in order to discriminate between coals not differing greatly in value, and of more importance, it is urged that the chief cause of error in sampling is that by the inclusion of too large or too small a quantity of impurities, the sample does not correctly represent the coal. If the "coal substance" is considered, that is, if the ash percentage is eliminated in computing the value of the coal, the sampling error is negligible. With duplicate samples the values should repeat themselves with no greater error than 0·1 per cent. or 0·2 per cent., and this is a degree of accuracy not contemplated by the makers of some forms of calorimeter, still on the market. It may be said in passing, that the "probable error" in the heating value, derived from the separate determinations of 24 samples taken from the same bottle sample, and distributed over a month, was 3·2 British thermal units.

The essential parts of a calorimeter consist merely in the bomb, properly so-called, the water jacket, the stirrer and the thermometer, but the variation in detail is legion. With regard to the bomb, if the constant-volume type of oxygen bomb calorimeter is selected, and this form is now considered to give the most trustworthy results, the interior surface should be of platinum, gold, or of some enamel that is not attacked by nitric or sulphuric acids. A replaceable lining is not satisfactory, as with wear, there is likely to be leakage between the lining and the corrodible metal. Such leakage is perhaps more detrimental to the life of the bomb than in effecting the accuracy of the results. The weight of the bomb is determined by the consideration that it must be strong enough to resist wear, and light enough to be easily handled. With light bombs it is possible to reduce the lag, and a low total water factor may be obtained, but if the water value is made too small the cooling correction is liable to be troublesome and subject to rather large error. On the other hand, when a bomb of light weight and consequently low capacity is used, high pressures must be employed to ensure complete combustion of the charge, shortening the life of the bomb. A stirred water jacket is considered desirable, with some mechanical arrangement for stirring the water, in order to maintain equable temperature throughout. A complete water jacket is preferable, since by such an arrangement the effect of variation in room temperature is minimised. Further, if the calorimeter is provided with a water seal "that part of the heat transfer equation,

$$\theta = \theta_0 (i - e^{-kt}) + \int_0^t f(t)\, dt$$

which has to do with the correction factor, $\theta_0 (i - e^{-kt})$ may be definitely known and controlled." This arrangement is attended with an economy of time, for evidently if the cooling constant of a calorimeter is known there is no need to make the preliminary and final rate observations. A form of construction similar to that the Dewar flask suggests itself since it might be inferred that the cooling correction would not enter into the calculation or could be kept below an appreciable amount. Messrs. Davis and Wallace do not approve of this obvious suggestion, for their experience shows that there is not only a measureable heat exchange in such a system, but that the type of apparatus is less convenient than the water jacket and there is no gain in accuracy.

The form and manner of stirring are both important. The object is to secure an efficient mixing while producing as little heat as possible, since the amount is difficult to control and to measure. A turbine form, in which the propeller blades are carefully designed is best adapted to the closed calorimeter. The blades are required to move the greatest amount of water for a given speed with the least slip, and consequently with the minimum heat input. The increase in temperature should not exceed 0 deg. to 0·01 deg. C. per minute for the average water-equivalent value of the bomb. The turbine should revolve about 500 r.p.m.; at a lower rate the water is liable to be inefficiently mixed.

There are, of course, several devices for measuring temperature which, with proper precautions, can be relied upon to give accurate results, displacing in general favour the mercurial thermometer, whose efficiency as an instrument of precision has not the high character with which for many years it has been credited. The stem bore is not uniform, but the effect of any irregularity may perhaps be eliminated if the calibration is carefully examined for very short lengths of stem. It may, too, be necessary to repeat the examination occasionally. When in use, there is a tendency for the mercury to adhere to the glass stem, which may or may not be prevented by an electric tapping device. Reading should be accurate to 0·001 deg. C. and the possible source of every error over that amount has to be carefully scrutinised. The demand for high sensibility and great accuracy suggests the use of either the platinum resistance thermometer, or the thermo-electric method, either form possessing some advantages. A resistance thermometer with appropriate measuring devices will certainly indicate variations of 0·0001 deg. C., and is well adapted for recording temperature in a single combustion calorimeter. Where a number of temperature readings in rotation have to be made, the thermo-electric method has some advantages, and while the sensibility is equal to that of the resistance method, the expense of installation is less.

The assembly of the various parts to produce a calorimeter that combines facility of operation with a high order of accuracy is shown in the annexed illustrations reproduced from the report mentioned. Fig. 1 shows the bomb consisting of a gold-plated monel-metal shell of about 600 c.c. capacity. This metal was chosen in preference to steel, because of difficulty experienced in depositing electrically a satisfactory coating of gold on steel. In any case, the gold plating is a troublesome and expensive process, but if the operation is successfully performed the gold surface is practically indestructible. The locking arrangement—an adaptation of the principle used in breech pieces of cannon—consists of a tough steel receiving nut and lock, so contrived that less than one-eighth of a revolution suffices for sealing. A circular gasket of electrician's solder completes the seal. This design possesses the advantage that if the lock wears out in service, a new one can be fitted to the same gold-plated bomb, but the authors' experience after three years of continuous and excessive strain is that under ordinary circumstances the locks remain as good as new.

The fittings and arrangement of the calorimeter and bath are shown in Fig. 2. The can shown at A, Fig. 2, is of strong sheet brass. An electrode consisting of ¼ in. brass bolt provided with a stiff brass spring for contact with the bomb plug is let through a hole in the can bottom, and is insulated from the metal can by means of a sleeve and washers of hard rubber. The electrode and a similar device on the jacket serves to establish an insulated electrical path from outside the apparatus to the fuse holder inside the bomb. The

Fig. 1. VERTICAL CROSS SECTION OF BOMB.

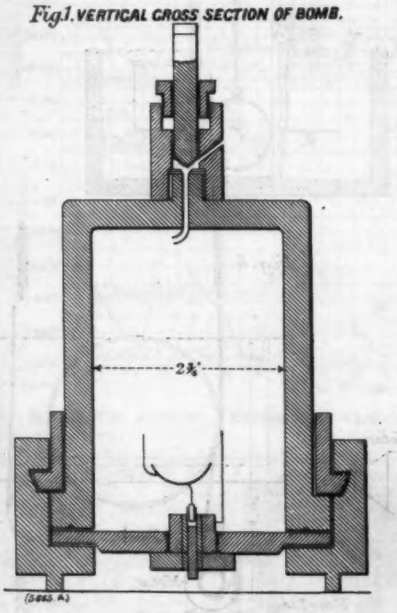
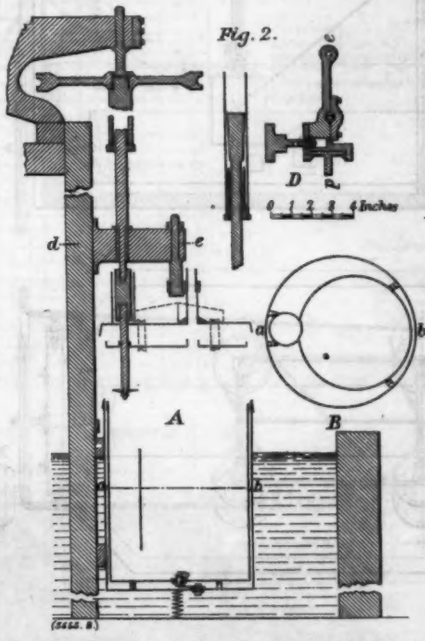


Fig. 2.



* The United States Bureau of Mines, Van H. Manning, Director; *A Convenient Multiple-Unit Calorimeter Installation.* By J. W. DAVIS and E. L. WALLACE. Washington: Government Printing Office [Price 15 cents].

can is supported in the jacket by small studs of ivory mounted in conical brass tubes and soldered to the bottom and surface of the jacket can. This is also made of heavy sheet brass, and is provided with a cover of brass ground to a watertight fit. The cover has a thin sheet brass water seal, in order that when the calorimeter is in place and the cover brought down snugly, the water seal is in contact with the surface of the water in the calorimeter can, preventing any evaporation into the space between the calorimeter and the jacket. The can is held to the vertical T-bar of the frame, but can slide vertically. The heavy brass spiral spring shown in Fig. 2 is of such strength that the can when charged is held vertical with its top slightly above the surface of the tank water. The stirrer well soldered to the can is shown at B, Fig. 2. The arrangement for stirring can be seen at C, in Fig. 2. The upper part of the stirrer shaft is a brass tube, into which the lower part telescopes. This latter has a conical piece screwed to the end and engaging a receiver at the lower end of the shaft tube, when the whole calorimeter is lowered into place. The lower bearing of the stirrer shaft is carried by the lid bracket D, held to the vertical T bar of the frame by a clamp to fix the lid in any desired position. The jacket can and cover are totally immersed in the water of the tank during an observation, and the position of the propeller stirrer is such that when the calorimeter is charged and the lid closed, the stirrer propeller has always the same position in the stirrer well. Electrical arrangements are provided to adjust the temperature in the calorimeter can to within 0·01 deg. C. of that desired.

Owing to the number of determinations required it is found convenient to mount six calorimeter units in the way indicated in Figs. 3 to 6. A perspective view is given in Fig. 7. The whole framework is bolted to the bottom of a stone tank, 8 ft. long, 3 ft. wide, and 17 in. deep. A brass tube, 9½ in. in diameter, runs through the centre of the tank at the end of which the stirrer is mounted. This has the form of a small motor boat propeller and is driven by means of the pulley shown. The speed of the stirrer is about 200 r.p.m., and is worked by ½-h.p. motor. The same power works the stirrers for the individual calorimeters, but here the speed is said to be 750 revolutions a minute; a speed that certainly seems excessive.

Fig. 3.

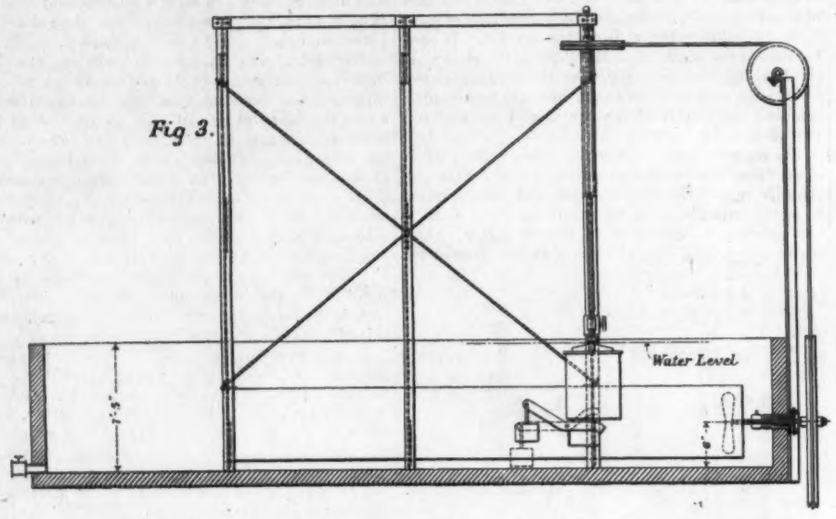


Fig. 4.

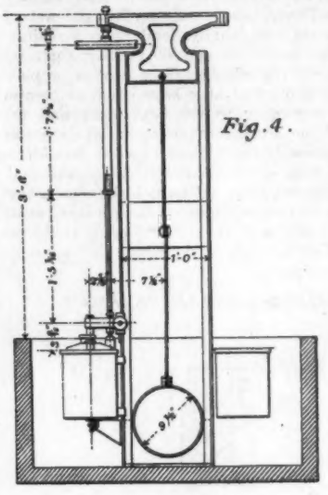


Fig. 5.

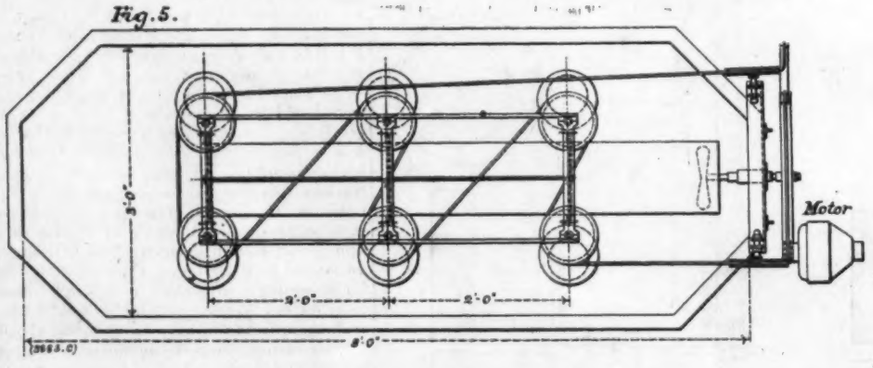


Fig. 6.

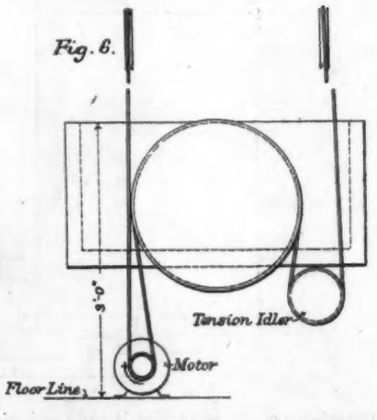


FIG. 7.

FIGS. 3 TO 7. INSTALLATION OF A GROUP OF SIX CALORIMETERS.

The temperature of the tank water is kept at 30 deg. C., a higher temperature than that of the laboratory, generally. Hence to maintain this heat it is necessary to let hot water flow into the tank, and an additional source is furnished by means of twelve 120-watt carbon filament incandescent lamps let into the tank walls, controlled by a sensitive toluene thermostat. No trouble has arisen from lag in the thermostat with consequent reduction in available sensibility. The steadiness of temperature which it is found possible to maintain is illustrated in Fig. 8. Curve (1) was plotted from the readings of a mercury thermometer placed near the point where the water enters the stirrer tube. Curves (2) and (3) exhibit the readings of two different resistance thermometers placed at opposite sides of the tank. The period of curve (1) is longer than that of the other curves. This arises from the closer agreement between the room temperature and the thermostat setting for current. There is, too, some slight difference of phase in the other curve.

The result of a rigorous discussion of the effect of the whole variation is to show that the maximum possible error is negligible.

Thermostat control is also used in maintaining constant temperature in the water for the calorimeter. The plan is found to be simple and more expeditious than that usually employed of mixing water and ice in a flask and measuring a given volume. The water used in previous determinations is allowed to flow into a 20-gallon tank, and the work of the thermostat in this case must be arranged to permit the passage of cold water. Ice water is kept in a tank at a higher level than the 20-gallon reservoir, and is allowed to flow into the lower tank by a valve operated by a magnet in the thermostat circuit. The tank water is stirred by a 4-in. propeller driven by a small fan motor, and practically it is found that the temperature of the water is kept constant to within 0·01 deg. C. A large automatic pipette serves to measure the quantity of water desired. The pipette is provided with a overflow pipe and glass stopcocks, and as the water is measured always at the same temperature one calibration point is all that is needed, and the water is delivered directly into the calorimeter pail. It is by attention to such details that the rapidity of manipulation has been increased. With the old calorimeters an observation required from 15 minutes to 18 minutes. It is now found that 8 minutes suffice and, further, since about 6 minutes are required for the calorimeter temperature to reach equilibrium after the firing of a charge, the operator has time to set up a second calorimeter in the interval and can work two instruments in rotation.

Platinum resistance thermometers having a sensibility of about 0·0005 deg. C. and calibrated to 0·001 deg. C., are used to measure the temperature within the calorimeter. The apparatus necessarily includes a thermometer bulb, a suitable bridge, and a galvanometer for measuring resistances. The form of thermometer which has been found satisfactory is of the four-lead type. The sensitive element consists of a coil of 0·1 mm. pure platinum wire, about 1 m. long, wound non-inductively on a mica form. The resistance of the coil is approximately 25 ohms at 0 deg. and 35 ohms at 100 deg. C. The thermometer has practically no lag and is constant. Though trouble will come from wear, those who use these delicate instruments will have their own methods of detecting and remedying the source of error.

The form of bridge is a matter on which considerable ingenuity can be expended where it is necessary to obtain readings carried to 0·001 deg. C.

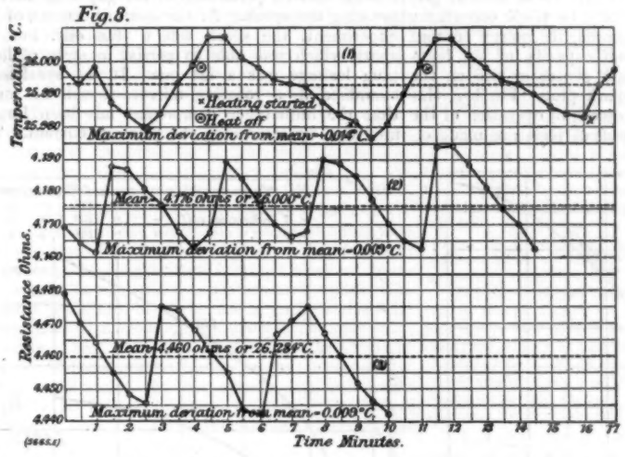


FIG. 8. CURVES SHOWING TEMPERATURE VARIATIONS IN CALORIMETER TANK.

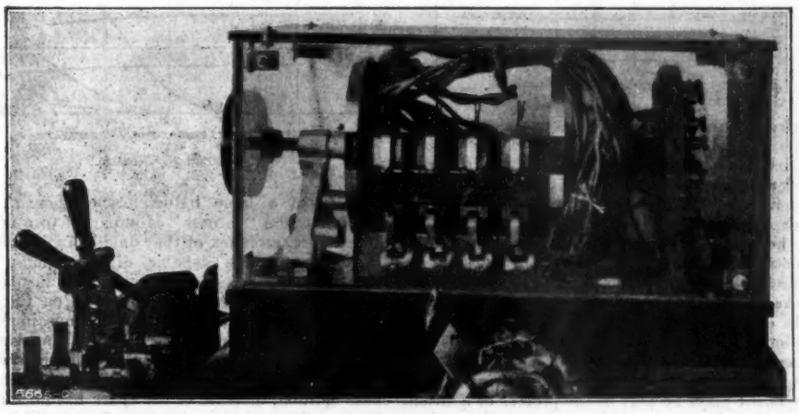


FIG. 10. SWITCH FOR USE WITH ONE BRIDGE AND ONE GALVANOMETER, AND THEIR CALORIMETER EQUIPMENTS.

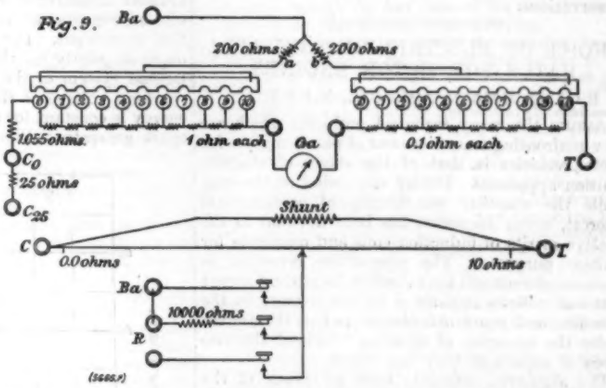


FIG. 9. SCHEME OF BRIDGE FOR CALORIMETER THERMOMETER. C, Co, C25, COMPENSATING LEADS; T T, TEMPERATURE LEADS.

The form finally adopted is shown in Fig. 9. When used with the thermometer just described a range of 1,000 deg. C. is possible, a much greater range than is needed in combustion calorimetry. In order to avoid the use of all amalgamated switch contacts Messrs. Davis and Wallace proposed the use of a "shunted slide wire of sufficient range to take care of the actual calorimetric measurement, the ballast resistance being controlled by switches not to be shifted during the measurement." This slide-wire principle is preserved in this form of bridge which, it is urged, is especially adapted to fuel calorimetry. A ballast resistance of 25 ohms is provided. This resistance may be inserted in the compensating arm of the bridge, altering the range of the outfit proportionately. "Another advantageous feature is the use of three contact keys, one with 0 resistance in series with the battery, one with a resistance of 1,000 ohms and one left blank for the insertion of any resistance desired. When the resistance of the thermometer is changing rapidly, the high resistance key furnishes a convenient means of following the charge approximately without at any time having excessive current going through the galvanometer."

Of the galvanometer it is sufficient to say that it is desirable to get the best instrument possible, especially as regards sensitivity. Since the bridge may be read to 0·00005 ohm, the galvanometer should be sensitive enough to indicate a difference of that magnitude. Obviously it is necessary to mount the galvanometer in such a manner as to render it free from vibration. The character of the support must be decided by the conditions of the laboratory.

A feature in the American installation is a "distributor switch" which permits the use of one bridge and galvanometer with three calorimeters. Not only are all the circuits, firing, heating and thermometer, shifted by one operation, but by the device two thermometers in the same bath, or the same calorimeter, can be compared. By using an extra set of contacts, standard resistance can be inserted, temporarily or permanently, permitting both the checking of the total bridge resistance when desirable, and providing means for determining the absolute resistance of the thermometers at fixed points. The essential features shown in Fig. 10 consist of "a central cage mounted on the spindle and carrying 16 spring-actuated copper contact pieces, held by hard rubber bars, the thermometer switch, and two double pole four-way rotary switches mounted in hard rubber on the same shaft as the thermometer contacts and serving to shift the heating and firing circuits. The master contact pieces of the thermometer circuit are of copper, and are bolted securely through the hard rubber switch base. Terminals are soldered directly to these circuits and connected in the same manner to the bridge terminals."

The calibration of the bridge may be effected by comparison with a similar bridge, calibrated and fully tested, and such a process is described here with full examples. But few would care to undertake the task except as a parergon. Such niceties are best left to a specially-equipped laboratory. The ordinary routine furnishes sufficient opportunities for the display of skill and ingenuity in eliminating the sources of error that are inevitable. Among these may be mentioned the "cooling error;" the effect of difference in time required by special quality coals to complete the combustion reaction; and of the possible deposition of moisture in the calorimeter can, refinements that are too little considered in the rather rough methods of fuel calorimetry that frequently obtain. But if small corrections are omitted one likes to know the amount so neglected and its effect on the final results. From this point of view, the careful analysis of Messrs. Davis and Wallace is of the utmost importance. The value of such researches is not diminished because, practically, there may be an error of 0·1 per cent. caused by variations in the nature of the impurities attaching to the sample, and possibly even a larger uncertainty arising from change of moisture content during the time between the moisture and the calorimeter determinations. There may be other causes, which tend to create apparent discrepancies

such as the loss of gas between the time of crushing and sampling the coal, though of course the value assigned by the calorimeter refers to the condition of the sample when brought under test. It is satisfactory to know that the Bureau of Mines, with the apparatus described, has been called upon to make some 40,000 calorific determinations. The keenness of the American engineer in seeking for accurate efficiency results is amply demonstrated, and it would be well if more attention were paid in this country to the calorific value of fuel. The "litharge" method of coal testing has not much to recommend it, but the Mahler bomb apparatus, and the sodium peroxide bomb calorimeter are comparatively inexpensive, and furnish results on which reliance can be placed, certainly for differential observations.

CHOICE OF ELECTRIC IGNITION APPARATUS FOR MOTOR ENGINES.

By J. D. MORGAN, A.M.I.C.E., M.I.E.E.

AMONG the many technical problems which are now confronting manufacturers of petrol engines for motor vehicles is that of the choice of electric-ignition apparatus. During the period of the war, while the question was largely of controversial interest, much discussion has been devoted to the relative merits of induction coils and magnetos for ignition purposes. The prospective reversion to peace conditions and the necessity for settling urgent post-war policies imparts a serious interest to the question, and many manufacturers find themselves under the necessity of deciding which of the two types of apparatus they will employ.

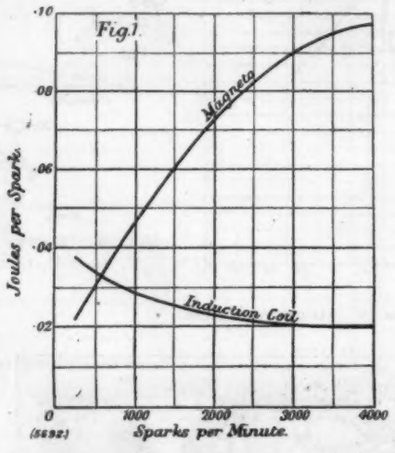
The argument generally used in favour of the induction coil appears to be so overwhelmingly forcible that many have been led to foretell speedy extinction of the magneto. In the minds of others, the argument is resisted not so much by a reasoned conviction as by an instinct that somewhere it conceals a fallacy.

As is well known, the use of electricity on motor vehicles for lighting and engine-starting purposes, will, in the immediate future, be more general than in the past. An essential component of every lighting and starting equipment is an accumulator. Seeing that this provides an ever-ready supply of electricity, the question is asked: Why employ an additional source of energy in the form of a permanent magnet for ignition, when a reduction of first cost and total weight can be gained by utilising the energy of the accumulator? When to this question there is added the statement that the induction coil gives a better performance at engine-starting speed than a magneto, it is without doubt a difficult matter for anyone not familiar with the intricacies of the subject to find a sufficient reason for retaining the magneto.

On behalf of the magneto, it has been urged that possible failure of the accumulator is more serious in its consequences when ignition depends on the accumulator than when a magneto is provided. This argument will be completely nullified if the engine makers decide, as many probably will, to dispense with the engine-starting handle. Should the accumulator fail, starting of the engine will then be equally impossible with either type of ignition apparatus.

Popular discussion seems to have been centred chiefly on the more obvious but secondary points, and to these such publicity has been given that by some they appear to be regarded as the essentials. The object in the following is to give a short account of what, in the writer's opinion, are the fundamentals on which any comparison of the two rival ignition appliances should be based. It is not suggested that comparison should be restricted to these, or that this account deals exhaustively with the subject. Reference to several important matters has been omitted because they are sufficiently well known. The aim is to focus attention on those facts which form the natural starting point in a systematic investigation of the properties of the two types of apparatus.

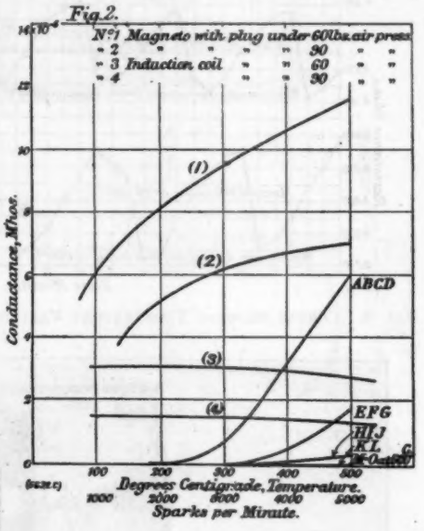
Before examining the results of tests on representative spark generators, it is important to consider in general terms one or two facts connected with high-tension sparks and explosive gas mixtures. A high-tension spark is composite in character. When viewed in a rotating mirror it is found to give a complex image. It is unnecessary for the present purpose to discuss this image in detail, and it is sufficient to state that the image shows an initial bright line which has been termed the capacity component, and a protracted or drawn-out portion which has been termed the inductance component. The energy content of the capacity component is usually small as compared with the total energy of the spark, and the greater proportion of the energy is, therefore, to be found in the inductance component. So far as the writer is aware, no means exist for measuring directly the energy content of the capacity component, and any quantitative estimate has, therefore, to be based on indirect measurements. Nevertheless, certain precise statements can definitely be made concerning this component. For example, its energy content depends jointly on the self capacity of the high-tension system of the spark generator and on the sparking voltage of the spark plug. Further, this energy is constant for all speeds of operation of the spark generator. When output tests are made on



spark generators, the results are sometimes expressed in joules per spark, and this quantity is plotted against speed. Such tests take account of the total spark energy, and seeing that the energy of the capacity component is constant, the differences in spark energy with speed, which the results show, can be taken as indicative of variations in the inductance component.

Having in mind the dual character of the high-tension spark, the question arises as to whether both components contribute to the process of ignition. Investigators appear to be generally agreed that ignition depends solely on the capacity component, and that in consequence, the inductance component plays no part in the process of ignition. This being the case, it is important to know how the capacity component of a magneto spark compares with that of an induction-coil spark. Measurements made on typical spark generators show that the self capacity of a magneto is greater than that of an induction coil. Therefore, with the same spark plug setting the magneto gives the more effective spark for ignition. The quantities involved are, however, very small, and, therefore, to avoid any suggestion of hair splitting, it will be assumed that the energies of the capacity components of magneto and induction-coil sparks produced by what might be termed standard apparatus, are substantially the same. It follows that with similar plug settings, magneto and induction-coil sparks would function, approximately, equally in the ignition of a given gas mixture. Whatever difference exists is in favour of the magneto.

If the inductance component contributes nothing to the process of igniting the gas, it is important to ascertain whether it performs any useful function. So far as ignition is concerned, the answer is in the negative, but the existence in the spark of a large inductance component is an index of a most important quality of the spark generator. The serviceability of a spark generator is largely dependent on the spark plug or plugs with which it is employed. Insulation leakage at the plug due either to deterioration under the influence of heat or accumulation of deposits is a common occurrence, and this has a detrimental effect on the performance of the spark generator. The effect is made very evident in a simple experiment. Take a small induction coil of the trembler pattern, and insert in series with the primary a variable resistance. Connect the secondary terminals to a spark gap and adjust the primary current until regular sparking just occurs at the gap. Then spray a very fine film of moisture over the gap insulation. It will usually be found that sparking ceases. Now increase the primary current, and the sparking re-appears. By making the primary current sufficiently strong, a large amount of leakage can be permitted at the gap without suppressing the spark. At the commencement of the experiment, the spark was a thin one, but the spark which was able to persist in spite of large plug leakage was a fat one. If the sparks are examined in a rotating mirror, it will be found that the inductance component has been largely increased by increasing the primary current. The



presence of a large inductance component (by which so-called "fatness" is imparted to a spark) is, therefore, an index of that quality by which the spark generator is capable of overcoming the extinguishing tendency of defective plug insulation.

As regards the action of the spark on the gas, there still appears to be a good deal of misapprehension on a certain point of practical importance. Notwithstanding the systematic investigations which have shown that, provided a spark is sufficient to cause ignition, increase of the spark has no further effect on the explosion, many engineers still persist in the belief that the rate of development of an explosion and the maximum pressure attained can be increased by increasing the spark. It is quite easy to understand how this belief has arisen. After replacing the ignition apparatus of an engine under test by one capable of giving larger sparks, it has repeatedly been found that the power of the engine is increased. From this observation, the conclusion is deduced that the increased power is due to the sparks. Actually the increased power is due to greater regularity of sparking. It has been demonstrated beyond the region of doubt that provided a spark is sufficient to ignite a gas then with any existing spark-ignition apparatus for internal-combustion engines, the subsequent development of the explosion is independent of the spark. With thin sparks and defective plug insulation, irregular sparking may occur. Keeping the conditions the same, and using fat sparks, this irregularity is diminished, or eliminated, and increased power results.

In the light of the above, a test on two typical spark generators will now be examined. Fig. 1 shows the relationship found between speed of operation and total spark energy with a magneto

and an induction coil, the latter being of the cam-operated contact-breaker type, which is the real rival of the magneto. The magneto was of the wound-armature type. Both spark generators were of high-class manufacture, and were representative pieces of apparatus. Further, both were designed for duty on the same class of engine. The results shown in Fig. 1 can be taken as typical of the performances obtained with the two kinds of ignition apparatus. It will be noticed that whereas the magneto spark energy increases with speed, that of the induction coil falls. At low speeds, the spark energy of the induction coil is rather higher than that of the magneto spark. In this connection, it is also necessary to remark that with induction coils sparks can be obtained at lower speeds than are ordinarily possible with magnetos, although with recent types of magnetos very low-speed sparking is now obtainable.

From the earlier observations made in this article, it will be evident that curves such as those shown in Fig. 1 give no indication whatever of the relative incendivity of the sparks (or their relative ability to cause ignition). The energy of the active portions (or capacity components) of the sparks is small in comparison with the quantities recorded in the graphs and remains constant, being independent of speed. So far as ignition is concerned, it has already been indicated that whilst the balance of advantage is in favour of the magneto spark, yet for practical purposes, the sparks from the two kinds of generators can be regarded as approximately equal. The curves given are, however, useful as indicating the variations with speed of the spark-inductance components, and, therefore, showing the relative ability of the spark generators to overcome adverse plug conditions. At low speeds, the balance is slightly in favour of the induction coil, but at ordinary working speeds the balance is greatly in favour of the magneto.

In a recent article,* the writer described the results of tests on spark-plug insulation at different temperatures. One of the diagrams shown in that article is reproduced in Fig. 2. In this diagram the curves A to M indicate the increase of plug insulation conductance (or leakage) with increase of temperature, the letters denoting different samples. The curves 1 to 4 show what leakage was required to put out of action a magneto and an induction coil at different speeds of operation. The spark generators were the same as those used in the test shown in Fig. 1. It will be seen that the magneto curves (1 and 2) rise with increase of speed, whilst the induction-coil curves (3 and 4) fall. It will also be seen that these confirm the statement made above that for overcooming the adverse effects of plug insulation leakage the magneto is greatly superior to the induction coil.

In the choice of apparatus on such considerations as those outlined in this article, the determining factor is the one which the engine-maker regards as the more important. If he requires a spark at a lower engine speed than can conveniently be obtained from a magneto, and considers it unnecessary to safeguard the user against loss of power, consequent upon irregular ignition at ordinary running speeds, he will choose a coil, but if he considers that the low-speed performances obtainable with modern magnetos are satisfactory, and that the greatest possible immunity should be provided against loss of power due to plug insulation leakage at ordinary running speed, he will choose a magneto.

It must be admitted that at first sight the induction coil is a very attractive form of spark generator, and there is no doubt that it is capable of giving good results. But now that the relative properties of the two types of apparatus are beginning to be more clearly understood, it is evident that the flush of enthusiasm which was at first excited by the later types of induction-coil apparatus is beginning to wane. The latest tendency in induction-coil design is to obviate the falling characteristic shown in Figs. 1 and 2, and produce a rising characteristic, such as that possessed by the magneto. Only a few proposals have yet appeared, but those which are now in existence clearly show that the limitation of the induction coil is being more fully realised. To obviate the falling characteristic, it is suggested to build the coil on magneto lines, and provide it with an electro-magnet in place of the permanent magnet, the electro-magnet being excited from an accumulator. As regards ignition, this gives no advantage over the magneto; it simply brings the induction coil level with the magneto. The result is obtained by substituting an electro-magnet, which is dependent on the accumulator, for a permanent magnet, which is independent of the accumulator. When this stage is reached, the issue is reduced to a choice of magnets.

* See ENGINEERING, November 8, 1918, page 513.

COAL-HANDLING APPLIANCES AT THE COVENTRY ELECTRICITY WORKS.

By GEORGE FREDERICK ZIMMER, A.M.Inst.C.E.

By the courtesy of Mr. G. Tough, manager of the Coventry Corporation Electricity Works, and by arrangement with Messrs. Ed. Bennis, Limited, Little Hulton and London, the contractors for the plant for handling materials, the writer was recently permitted to inspect these works.

An account of the coal and ash-handling plant of this installation in its early stages has already appeared in the press; but as it has been completed within the last few months, and as some of the earlier plant has been replaced by arrangements which more adequately meet present-day requirements, no apology is needed for fully describing this important plant as it now exists. It is only necessary to dwell briefly on the earlier history of this important installation, dealing more fully with its latest developments.

As usual, in earlier installations, the Coventry Electricity Works started on a small scale, but it is now one of the few power stations which produce more electrical energy in the day time than at night, which apparent anomaly is accounted for by the enormous power required for practically all industrial establishments; the tall factory chimney, therefore, is conspicuous by its absence at Coventry.

When the time was ripe for the introduction of labour-aiding and time-saving devices, these were supplied by Messrs. Ed. Bennis and Co., Limited, in the form of automatic stokers of one or other of their various types, as well as the necessary conveyors and elevators. During the early stages the coal store was, and still is, in the old position, at the ground level and alongside the two first boiler-houses, there was therefore no other choice than to feed the boilers by means of inclined elevators, the receiving terminals of which reached into the coal store, and the delivery end conveniently high in the boiler-houses to feed the automatic stokers of the boilers. The driving gear for the elevators is all situated within the boiler-house proper, and even the levers which admit the coal to different parts of the store are so placed that the men in charge can control the coal supply in the store from their posts at the boilers. Two general views of the works are given in Figs. 1 and 2, on Plate II., while a general plan is given in Fig. 3, on page 38. Fig. 1 is a view from the canal side, showing at the extreme left the unloading terminal for the oldest part of the plant—the Lancashire boiler-house. The next unloading terminal is for the second boiler-house, which runs parallel with the water side, while the third receiving terminal serves the latest installation running at right angles to the canal side.

The latest additions to the plant for handling materials are the work of Messrs. Bennis and Co., Limited, to the requirements of Mr. G. Tough, and having overhead coal bunkers and ash plant in the basements.

Before going into the details of this plant, we will briefly deal with the terminal arrangements for the reception of the coal, including the new plant for the delivery of the coal from the barges to the above-mentioned older coal stores alongside the earlier boilers. The coal used is brought from the Warwickshire coalfields and arrives at the site by way of the Coventry Canal, which skirts the southern boundary of the premises, forming a bay sufficiently large for four or five barges to moor alongside.

The terminal requirements offer some difficulty and are decidedly out of the ordinary run. To begin with, the barges are long and narrow, with a capacity of only 30 tons each, or approximately the contents of three railway trucks, consequently any unloading device of the type more commonly in use would be of little use here unless of miniature dimensions and employed in sufficiently large numbers. If a grab was used in conjunction with the usual locomotive crane or telpher it would seriously imperil the frail wooden craft, besides which the grab would have to be exceedingly small in a barge only about 6 ft. wide. The writer has never yet seen a thoroughly satisfactory lay-out for handling coal out of a railway truck with a grab, and to handle in this way from the even narrower barges, though it may be possible, would not be desirable. Furthermore, two men would be required in the barge for trimming, and directing the grab, and one man in the telpher or crane cabin—three men in all—for conveying a very small quantity. A barge elevator would be a more likely proposition, and this was tried during the earlier history of the installation; it answered very well for the requirements at that time, but it also necessitated two men for trimming and feeding it, owing to the shallow depth of the coal in the barge, it was therefore removed to make room for the present plant in which hand labour had to be resorted to for clearing the barges.

If the writer may be permitted to suggest what, in his opinion, would have been the only alternative to the present arrangement of hand shovelling, he would say the pneumatic system, with which Messrs. Bennis have been so successful in handling ashes, which is also applicable for handling coal of the size used at Coventry, though the wet state of the fuel at certain seasons of the year presents some difficulty.

It has already been stated that the receiving bay is sufficiently extensive for four or five barges to be unloaded at the same time; there is a gang of five men in each barge (only two more than would be necessary with the use of the mechanical alternatives); they dispose of 30 tons in 1 hour, it is thus possible for 120 tons of coal to be shovelled out of the five barges into the conveyors on the bank simultaneously.

As will be seen from the plan, Fig. 2, there are five U-link conveyors skirting the whole of the frontage of the quay, and into these the men throw the coal by means of shovels, and feed three receiving towers. Iron plates are provided on either side of these conveyors forming a large V-shaped trough, of which the conveyor forms the base. The plates on the waterside are temporarily hooked on to the barges so that all spilling is avoided, the plates on the land side are fixtures.

Coal-receiving Plant of the Old Coal Store.—A general arrangement of the new coal-receiving plant for the earlier coal store (which has replaced the barge elevator) is shown in Figs. 4, 5 and 6, on page 39. It might be mentioned that the other four coal-receiving installations are so similar to this, that one description will suffice, and the differences will be understood by a glance at the general plan of the new power-house.

The U-link, wharf, or gathering conveyor A, B, C, runs slightly below the ground level and the portion A, B, is horizontal, this length coincides approximately with the length of the barges. From B to C, the conveyor ascends at a moderate gradient, and to a sufficient height to feed by gravity into the revolving feeding device or filler of one of Bennis's gravity bucket conveyors, as will be seen from Fig. 4. The return strand of the wharf conveyor is carried about 4 ft. above the working trough in order to be well out of the way of the shovelling operation from the barges to the conveyor. The tension terminal is situated at A, while the driving gear, with its two countershafts and gearing is at C. Since the conveyor follows the line of the bay which has a polygonal form, it cannot be at right angles with the rest of the plant, and an independent electro-motor for driving it is situated at D. Concerning the details of construction of the wharf and other U-link conveyors forming part of this installation, Figs. 7 and 8 will give full particulars of the troughs, the chains, the hexagonal driving, and the cylindrical tightening terminals, also of one of the idlers supporting the return strands. The gathering conveyor is 12 in. wide, 7 in. deep, and 12 in. pitch, it travels at 90 ft. per minute and is capable of handling 30 tons to 35 tons of coal per hour; the motor driving the conveyor is one of 5 h.p.

A good general idea of the wharf and its plant is given by the photographic view, Fig. 2, Plate II. The gathering conveyor is on the right-hand side of the receiving tower, while one of the barges on the left-hand side of the tower is being unloaded on to the U-link conveyor above described, which forms the terminal for the middle receiving tower. The conveyor which takes the coal into the boiler-house is in a culvert, while the conveyor seen connecting the boiler-house with the tower conveys the ashes to the barges.

From the U-link and the rotary filler the coal is delivered in regular charges into the individual buckets of the gravity bucket conveyor, the path of which is indicated by E, F, G, H, I, Fig. 6. The driving terminal is at G, and just before the chain of buckets reaches that point they are tipped into the hopper of an "Avery" automatic weighing machine, which in turn delivers to the feeding hopper over a second U-link conveyor running the whole length of the old coal store, in front of the Lancashire boilers, which are fed, as already stated, by inclined bucket elevators. The U-link conveyor in this coal store carries coal in both directions, and therefore both strands of the chain run for a certain distance in iron troughs. The arrangement being unusual is of some interest. The receiving hopper delivers into the upper strand,

PLAN OF COVENTRY CORPORATION ELECTRICITY WORKS POWER STATION.

(For Description, see Page 37.)

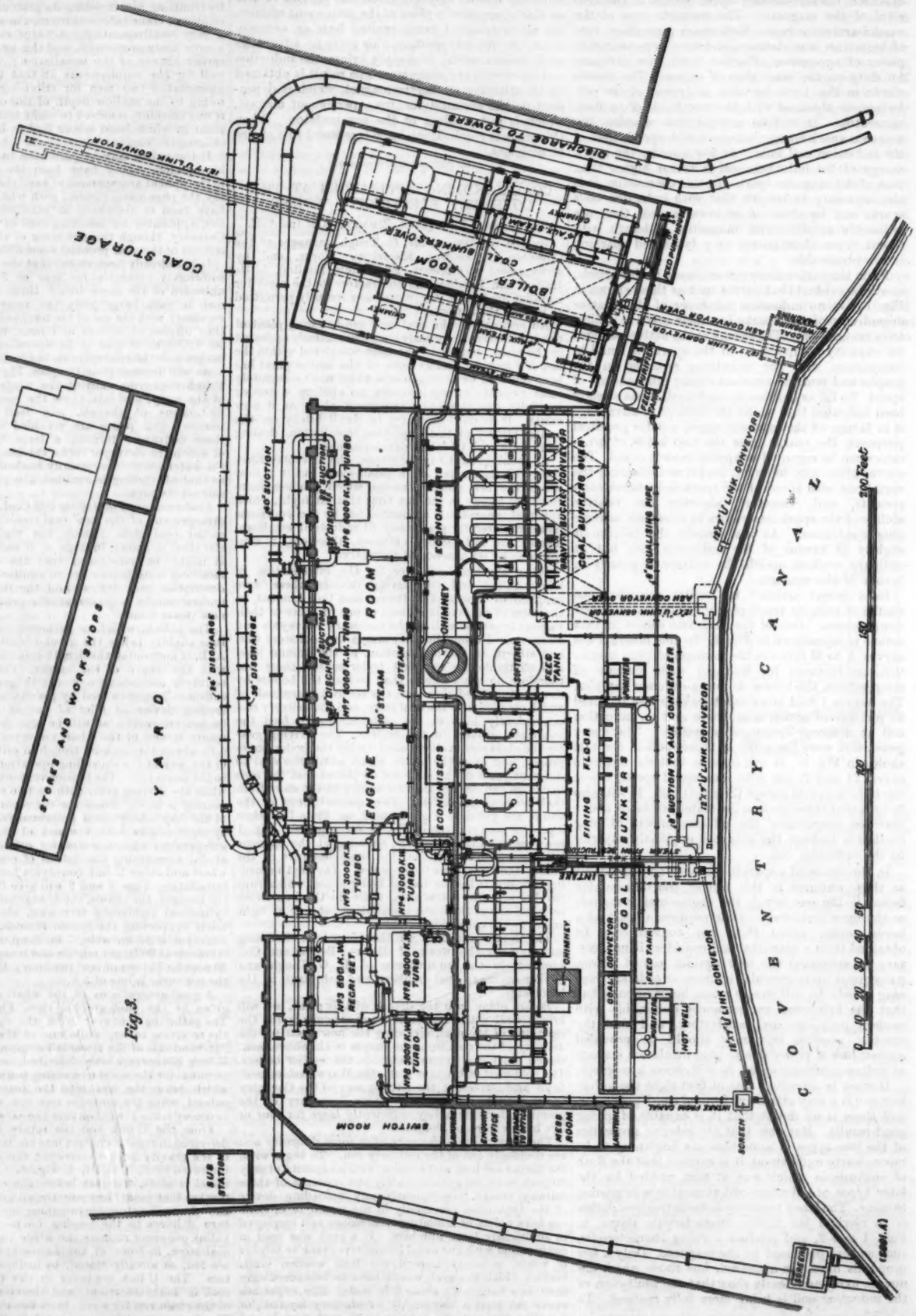
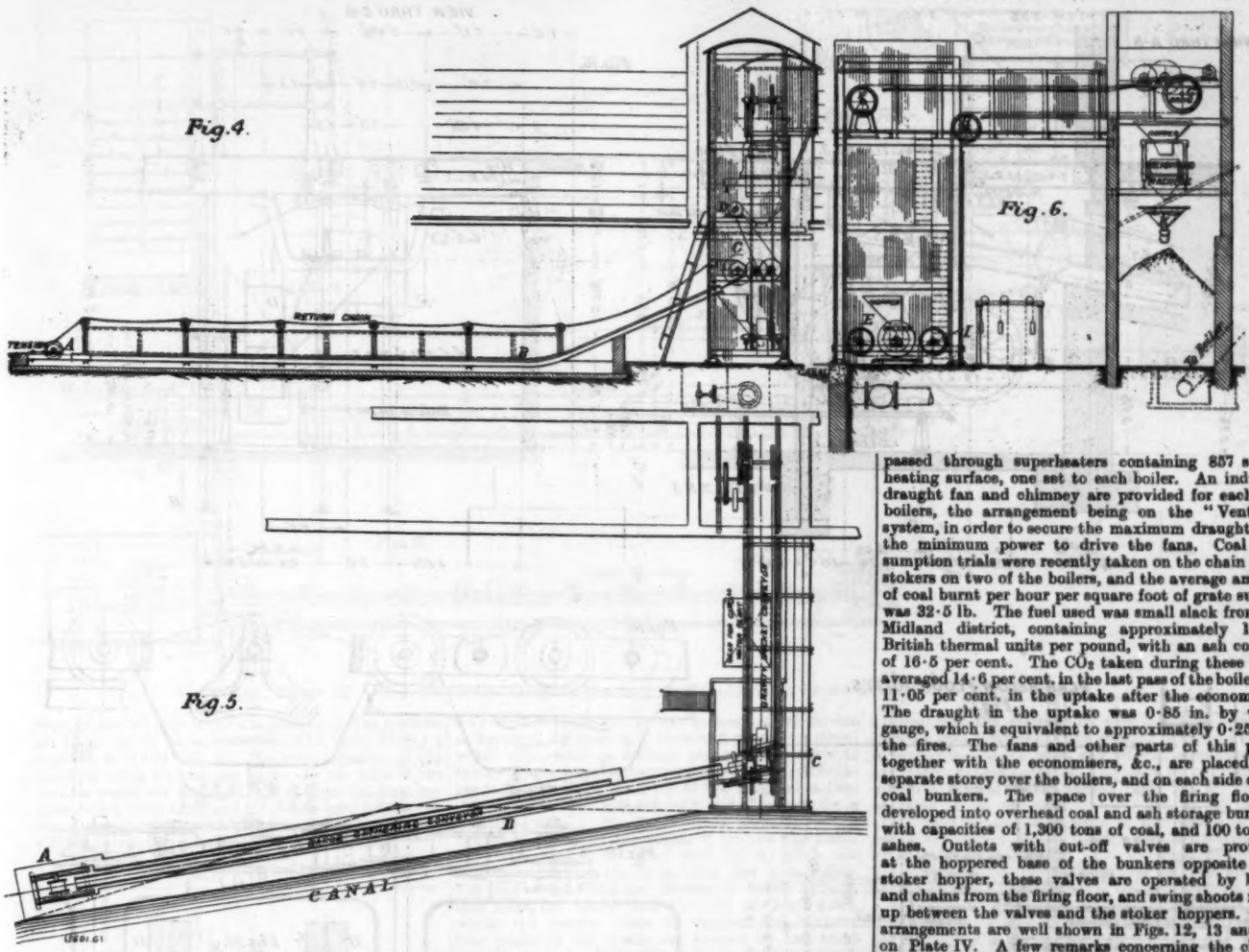
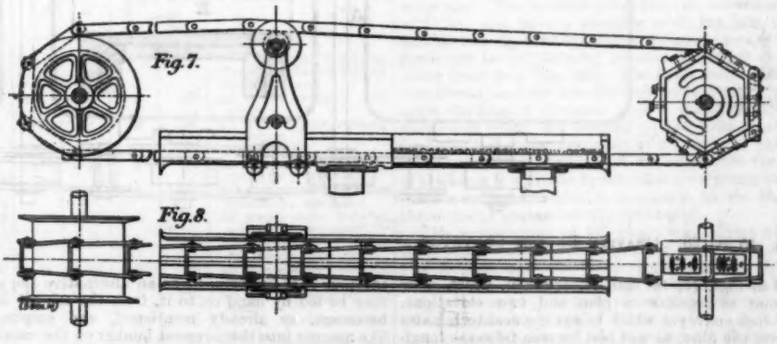


Fig. 3.

COAL-HANDLING PLANT; COVENTRY CORPORATION ELECTRICITY WORKS.



FIGS. 4 TO 6. COAL RECEIVING STATION IN THE OLD LANCASHIRE BOILER HOUSE.



FIGS. 7 AND 8. ELEVATION AND PLAN OF THE "LINK" CONVEYOR.

and the coal therefore travels in one direction from this point to replenish one-half of the store, if the portion of the store opposite has to be filled a slide in the upper trough is opened and the coal allowed to fall through into the lower strand, which naturally travels in the opposite direction. The coal is withdrawn from any part of the conveyor at either side of the feeding point by slides operated from the boiler-house, as already stated. A detail of such a slide may be seen in the drawing of the U-link conveyor, Figs. 7 and 8.

The New Boiler-House.—The skeleton structure of this building consists of rolled steel joists, channel and other sections, built together to form a steel framework; the spaces between the said steel joists, channels, &c., being filled in with panels of brickwork. A view of the latest boiler-house, before the panels of the end wall were built on, is shown in the photographic view, Fig. 9, Plate III. This view also shows the underside of the bunkers, but the gravity shoots feeding the coal to the stokers were not in place when the photograph was taken. This boiler-house contains eight large Babcock and Wilcox marine-type water-tube boilers, four at each side, facing each other (see photographic view, Fig. 10, Plate III), and each boiler is provided with two Bennis patent chain-grate stokers; each grate is 7 ft. wide, with an effective length of 12 ft. 6 in., giving a total grate area of 175 sq. ft. per boiler. Each boiler is provided with a set of Green's economisers, of 2,880 sq. ft. heating surface. The boilers are worked at 200 lb. per square inch pressure, and the steam is passed through superheaters containing 857 sq. ft. heating surface, one set to each boiler. An induced-draught fan and chimney are provided for each two boilers, the arrangement being on the "Venturi" system, in order to secure the maximum draught with the minimum power to drive the fans. Coal consumption trials were recently taken on the chain grate stokers on two of the boilers, and the average amount of coal burnt per hour per square foot of grate surface was 32·5 lb. The fuel used was small slack from the Midland district, containing approximately 10,000 British thermal units per pound, with an ash content of 16·5 per cent. The CO_2 taken during these trials averaged 14·6 per cent. in the last pass of the boiler and 11·05 per cent. in the uptake after the economisers. The draught in the uptake was 0·85 in. by water gauge, which is equivalent to approximately 0·25 over the fires. The fans and other parts of this plant, together with the economisers, &c., are placed in a separate storey over the boilers, and on each side of the coal bunkers. The space over the firing floor is developed into overhead coal and ash storage bunkers, with capacities of 1,300 tons of coal, and 100 tons of ashes. Outlets with cut-off valves are provided at the hoppered base of the bunkers opposite each stoker hopper, these valves are operated by levers and chains from the firing floor, and swing shoots make up between the valves and the stoker hoppers. The arrangements are well shown in Figs. 12, 13 and 14, on Plate IV. A few remarks concerning the chain-grates may not be out of place here. These grates are fitted with links having corrugated air spaces and half-lapped joints, which give an even unbroken surface at all parts of the grate. Dowels are provided at one side of each link which fit into corresponding recesses on the next link, thus if a link should break it is prevented from dropping out, and avoids the possibility of any holes appearing in the grates through which live fire and half-burnt coal might fall on to the return length of the grate. The grates are driven by belt from overhead line shafting, each being provided with change-speed gear, by means of which six variations of speed can be obtained on them. A patent safety friction clutch is also provided so that, should the torque be increased above what is required to drive the grate under normal conditions, the clutch slips and the grate is released from excessive driving stresses.

On February 5, 1917, trials were made to ascertain the actual horse-power required to drive these grates and their shafting. The plant driven was as follows:

Boilers Nos. 13, 14, 15, 16. Babcock and Wilcox marine type boilers, each fitted with two Bennis chain grates.

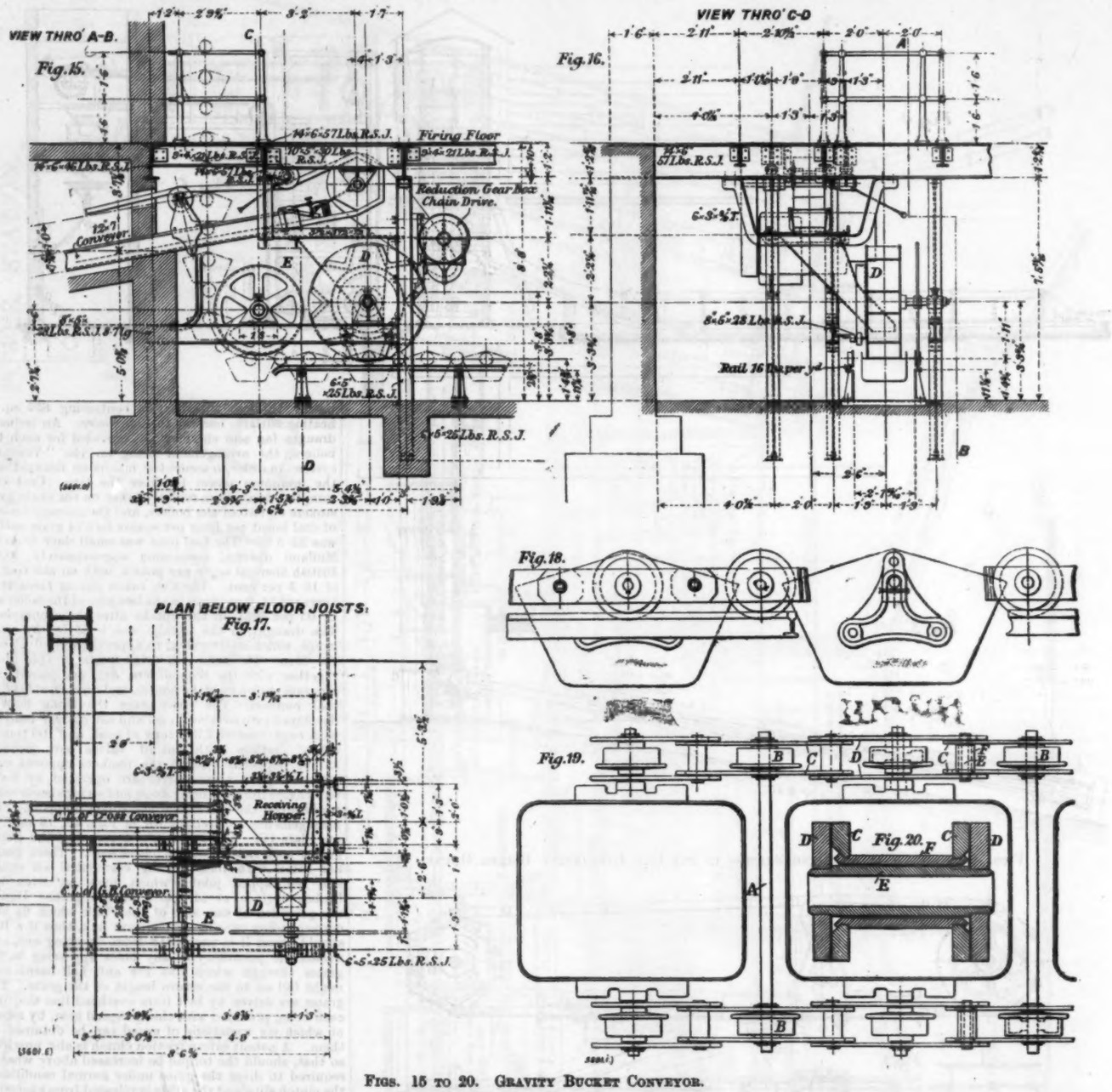
Eight Bennis chain grates, each 7 ft. wide, 13 ft. 6 in. centre 12 ft. 6 in. effective length, 90 sq. ft. grate area per grate—total grate area 720 sq. ft.

Shafting 2¼ in. diameter; 120 r.p.m. Total length, 101 ft. 3 in., with bearings varying from 9 ft. to 10 ft. apart, driven by belt (200 r.p.m. to 120 r.p.m.), in centre of length through chain reduction gear (reducing from 930 r.p.m. to 200 r.p.m.) by motor.

The results are given in the table on page 41.

The grates are so constructed that they do not project under the sill plates, an arrangement which prevents the latter from burning out, and owing to the construction of the sand seals at the sides, the grates may be withdrawn from the furnace without risk of causing damage. The ash and clinker passes over the back of the chain grate stokers and falls into

COAL-HANDLING PLANT; COVENTRY CORPORATION ELECTRICITY WORKS.



FIGS. 15 TO 20. GRAVITY BUCKET CONVEYOR.

hoppers built beneath the boilers, from which it is withdrawn by hand and trimmed into the gravity bucket conveyor.

Coal and Ash-Handling Plant of the New Boiler-House.—The general arrangement will be understood from Figs. 12, 13 and 14, on Plate IV, already referred to. To the left of the plan and elevation is shown a similar wharf, or gathering, conveyor as above, which is fed from the canal barges (see photographic view, Fig. 2, Plate II), and rises to point A, Fig. 12, on a substantial tower on the wharf side.

This elevation also shows the terminal pulley of the U-link conveyor which discharges by way of the coal shoot into the Avery weighing machine. After the weight of the coal has been recorded it is discharged at intervals into a U-link conveyor B, C, which, with a slight rising gradient, discharges into the rotary filling device D, of the main coal conveyor of the Bennis gravity bucket type.

As the transfer of the coal at this point is not easily understood from a drawing on so small a scale, a more detailed drawing of the construction is represented in Figs. 15, 16 and 17, annexed, which show the point of transfer in plan and two elevations. The U-link conveyor which brings the coal terminates just over the filler, as will best be seen from the longitudinal elevation, Fig. 15, which also shows the drive of the conveyor from an electro-motor. The cross-section and plan, Figs. 16 and 17, show that the distance from the centre of the gravity bucket conveyor to that of the U-link conveyor is only 2 ft. 6 in., the coal can therefore easily slide down by shoot into the filler D, which is operated by a starlike wheel which engages with one of the chains of the gravity bucket conveyor. The path of the gravity bucket conveyor is marked E, F, G, H; the full buckets from the filler D, rise over terminal E to F, and as they traverse between F and G, they can drop their load at any desired point into the four coal bunkers (see photographic view, Fig. 11, Plate III).

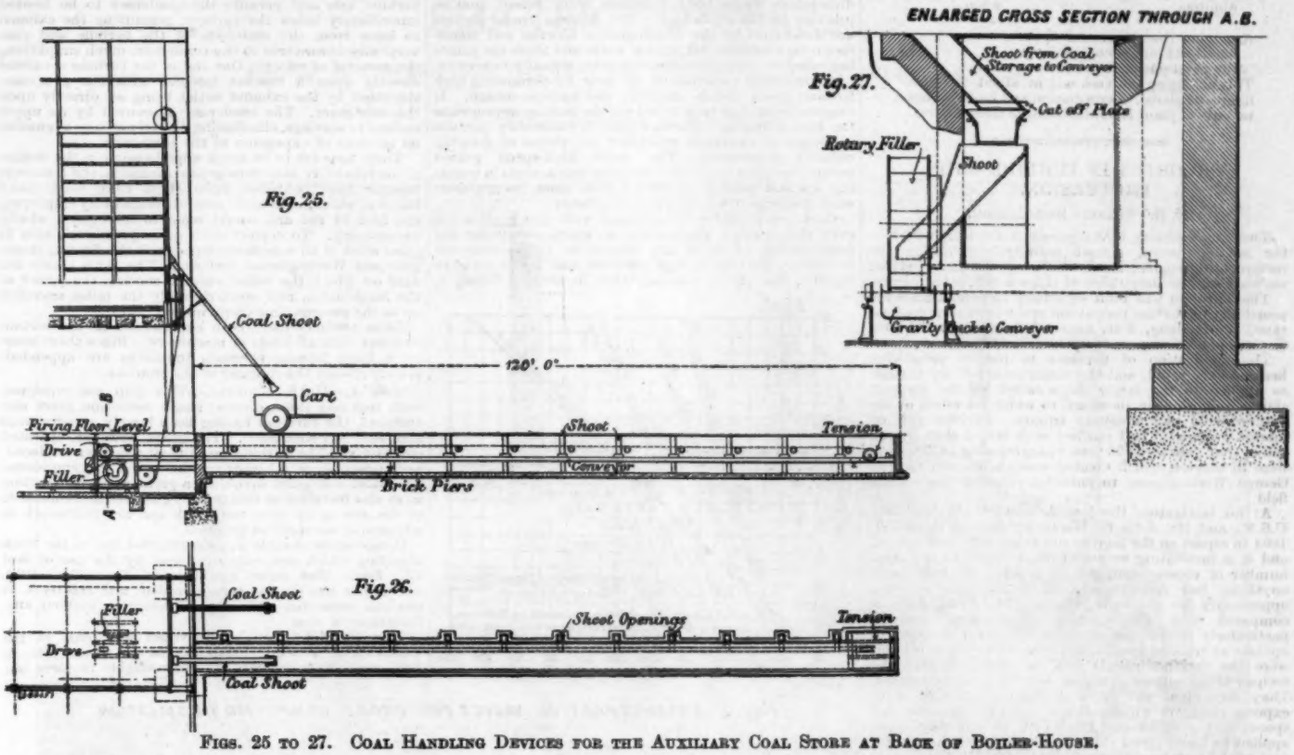
On its descent the empty conveyor traverses from G to H, and back to E, on its lower run. The same conveyor is used for taking the coal from an outside coal store (to be described more fully later) to any of the four coal bunkers, or as an alternative the ashes may be fed by hand on to it, from the ash pit in the basement, as already mentioned, and emptied in like manner into the foremost bunker on the canal side which is set aside for their reception, the gravity bucket conveyor can also deliver direct into the upper U-link conveyor on the wharf without passing through the ash bunker.

The ashes can be withdrawn at any time from this conveyor and discharged by a steel shoot into some of the empty barges in which the coal was brought. If it should at any time be desirable, either through lack of barges, or in any emergency, to discharge the ashes into road vehicles, an outlet is provided at L, by means of which the ashes can be loaded into carts; this can be seen from the photographic view, Fig. 2, Plate II.

The coal bunkers can best be seen in the cross-section, Fig. 13, Plate IV, with their two rows of outlets and radial cut-off valves, by means of which the coal is led to the automatic stokers of the boilers.

The Bennis gravity bucket conveyor is shown in

COAL-HANDLING PLANT; COVENTRY CORPORATION ELECTRICITY WORKS.



FIGS. 25 TO 27. COAL HANDLING DEVICES FOR THE AUXILIARY COAL STORE AT BACK OF BOILER-HOUSE.

Figs. 18 and 20, page 40, to a larger scale. The buckets are 18 in. by 20 in. and 9 in. to 12 in. deep, having a capacity of 2,160 cub. in., the total capacity of the conveyor being 40 tons per hour. To the sides of the buckets cams are attached which form the bearings upon which they hang and tip. The pin, marked on the drawing, when withdrawn, releases the bucket without interfering with any details of the chain.

Results of Trials of Bennis Chain-Grates (*see page* 39).

H.P.	Travel of Grates, In. per Minute.	K.W. Reading.	Number of Grates in Service.	Sq. Ft. Grate Area Operating.	
2·7	—	2·0	None	—	Shafting only, including Coventry Chain Company reduction gear.
5·1	6·0	3·8	8	720	All grates empty; full speed.
5·63	6·0	4·2	8	720	All grates under working condition; full speed (9th speed).
5·0	4·76	3·70	8	720	All grates under working condition; 5th speed.
4·62	4·0	3·45	8	720	All grates under working condition; 4th speed.
4·29	3·4	3·2	8	720	All grates under working condition; 3rd speed.
3·89	3·0	2·90	8	720	All grates under working condition; 2nd speed.
3·76	2·64	2·80	8	720	All grates under working condition; 1st speed.
3·63	6·0	2·7	2	180	No. 13. Both grates full speed.
2·95	2·64	2·2	2	180	No. 13. Both grates low speed.
3·98	6·0	2·3	2	180	No. 14. Both grates full speed.
2·95	2·64	2·2	2	180	No. 14. Both grates low speed.
3·08	6·0	2·3	2	180	No. 15. Both grates full speed.
2·95	2·64	2·2	2	180	No. 15. Both grates low speed.
3·08	6·0	2·3	2	180	No. 16. Both grates full speed.
2·95	2·64	2·2	2	180	No. 16. Both grates low speed.
5·63	6·0	4·2	8	720	All grates full speed.

The tipping of the buckets is accomplished by a weighted tripper, which, when placed in the required position, comes in contact with the above mentioned cams of the bucket and turns them over one by one. This tripping device is arranged with a balance-weight so that it automatically retains the position in which it is set, and either tips the buckets or allows them to pass as may be necessary. It is put in and out of service as required, by moving a lever and rollers are fitted which will ascend an inclined plane on the levers to reduce the shock and friction necessary. The chain forming the conveyor is made up of two identical endless strands, connected between each pair of buckets by a mild steel axle A, Fig. 18, 1 in. in diameter, which retains the gauge of the rollers B, to suit the track. Each strand is built up of links 12 in. pitch, the mild steel bars being 3 in. deep and $\frac{3}{8}$ in. thick. The individual links are alternately inside or outside links, the inside links C, carry the steel axles, whilst the outside links D, support the buckets. The joints of the chain are formed by two short lengths of heavy, hydraulic, solid drawn tube fitting into each other, E being the inner one, and F the outer one. The internal tubes have an outer diameter of $1\frac{1}{2}$ in., and have a shoulder to fit the hole in the outside link D, thus forming a distance piece, so that there can be no jamming between the inner and the outer links (see Fig. 20). The outer tube F is also shouldered, and fits into the holes of the inner link E, again forming a distance piece; these tubes, both inner and outer, are secured to the mild steel flats by being internally expanded at the ends, so that the inner tube forms the pin and the outer tube the bush of the joint, it will thus be seen that a very long bearing surface is given, which is necessary, as the links of these chains are not usually lubricated.

The construction of the chain thus allows of each link being formed into one solid piece built out of two bushes and two mild steel plates. By this method the whole chain can be built up without a single bolt or pin, the only parts not rigidly connected being the bearing surfaces of the bushes. It is therefore impossible for the chain to become disconnected in any way or for wear to take place through vibration or other causes which would in any way reduce the efficiency of the chain. In proportion to its strength and bearing surface this chain is claimed to be the lightest on the market.

The buckets are made of heavy steel sheets with brackets fixed on the sides to carry the trunnion supports and dumping brackets.

Special attention has been paid to the design of the rollers B, in order to ensure a long life and necessitate but little supervision. Instead of allowing the wheels to run on the connections between the links—which require an axle out of all proportion to the size of the wheel—a separate axle of mild steel is provided, the end of which is extended to form the trunnion on which the buckets are suspended. An oil reservoir is formed inside the rollers (which are cast hollow) which will hold about three months' supply of oil, the oil being inserted into the chamber by a syringe oiler through a spring dust-tight cap. The framing of the conveyor is constructed in the usual way, of mild steel channels and plates braced together; the track for the running wheels is formed of flat-bottom rails, $20\frac{1}{2}$ in. gauge, weighing 16 lb. per yard.

We have already seen some of the details of the conveyor support at the point where it receives its load, in Figs. 15, 16 and 17, while Figs. 21 to 24, Plate V, showing the driving gear of the gravity bucket conveyor above the coal bunkers, with its mild steel supporting structure gantrys and stairways, will give a very good idea of the minute attention which has been given to every detail.

External or Emergency Coal Store.—A space 120 ft. long, and as wide as the boiler-house, is available at that end of it which is remote from the canal. In order to accumulate the coal on this it is received and handled in precisely the same way as already described, but deposited into the last of the bunkers. Figs. 25 and 26, annexed, are an elevation and plan of the arrangement of conveyors and shoots for accumulating and reclaiming the coal; the building on the right-hand side will be recognised as the end of the boiler-house, and by filling the last bunker above the height at which the two shoots are connected the coal will descend by gravity and can be withdrawn, either by cart or formed into a heap. A portable scaffolding is arranged for, by means of which the cart for distributing the coal can also be used at a higher level. When reclaiming the coal, operations are always commenced at the point nearest the boiler-house. The culvert in which the U-link conveyor is erected is covered with cast-iron plates, and the coal can be fed through openings and shoots on to the conveyor, and when no more coal will run by gravity from the pile, the next opening is employed. Figs. 25 to 27 show, to a larger scale, the culvert, the U-link conveyor, and the shoot which feeds from the latter through a rotary filling device on to the main gravity bucket conveyor, taking the coal through the basement and up the other side into the coal store.

The cost of handling taken in fair average figures, would be approximately as follows:—

Handling the coal from the barges into the bunkers, for labour only.	4d. per ton.
Power required to drive main gathering conveyor, cross conveyors, and gravity bucket elevator.	$\frac{1}{4}$ h.p. per ton of coal handled.
Approximate power required to run the small inclined bucket elevator, and conveyor in old coal store.	$\frac{1}{4}$ h.p. per ton of coal handled.

The wharf conveyor requires ...	5 h.p.
The cross conveyor requires ...	3 h.p.
The gravity bucket conveyor requires	4 h.p.
Assuming that these conveyors handle 24 tons of coal per hour the total power required ...	12 h.p.

This will bring the cost out at about the same figures as above. Depreciation and interest capital cost of plant is not included in these figures.

PROGRESS IN TURBINE SHIP PROPULSION.*

By Mr. FRANCIS HODGKINSON.

THE extraordinary development of the steam turbine for land purposes, almost entirely supplanting the reciprocating engine, rendered the application of steam turbines for the propulsion of ships a natural sequence.

The Turbinia was built especially to demonstrate the possibility of turbine propulsion and was of torpedo-boat type, 100 ft. long, 9 ft. beam, 3 ft. draught, 44 tons displacement, and was completed in 1895.

The application of turbines to marine propulsion became very rapid, and the construction of the turbine as applied to the larger ships called for the greatest skill of the designer, in regard to which no words of the author could pay adequate tribute. In 1904 turbine marine propulsion had reached such stages that by the end of that year some 26 vessels, aggregating 147,000 h.p. were in service, which created enough interest to lead George Westinghouse to consider entering the marine field.

At his instigation the late Admiral G. W. Melville, U.S.N., and Mr. John H. Macalpine, visited Europe in 1904 to report on the marine situation as it then existed and it is interesting to note that, in spite of the large number of vessels equipped in Europe, the report was anything but encouraging. They did not see any opportunity for the steam turbine for driving ships as compared with the existing reciprocating engines, particularly in the case of ships which are required to operate at cruising speeds, and they showed how inferior were the turbine installations as compared with the reciprocating engine installations when so operated. They recognised the applicability of the turbine to express steamers which always operated at their full speed, and pointed out their lack of economy when applied to lower speed ships which comprise the greater part of the merchant marine. They said, "If one could devise a means of reconciling in a practical manner the necessary high speed of revolution of the turbine with the comparatively low speed of revolution required by an efficient propeller, the problem would be solved and the turbine would practically wipe out the reciprocating engine for the propulsion of ships. The solution of this problem would be a stroke of great genius," and proceeded some time thereafter themselves to become the genii by designing a tooth reduction gear adaptable to such service, embodying the now well-known floating frame. Mr. Westinghouse at once recognised the great possibility of its construction, and though considerably delayed on account of the financial depression at that time, a reduction gear expected to develop 6,000 h.p., reducing from 1,500 r.p.m. to 300 r.p.m. was tested in 1909.

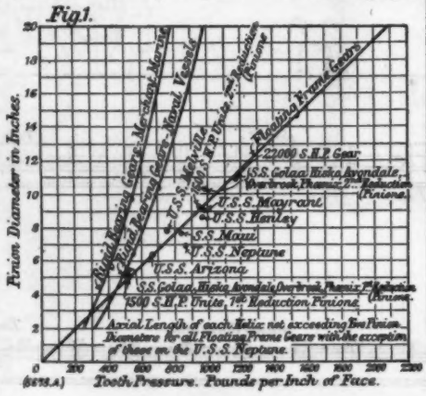
The essential features of the floating frame gear will be but little referred to here in view of the many articles that have been written on this subject by Mr. Macalpine.†

The point most freely discussed in connection with reduction gears is the permissible tooth pressure per lineal inch of tooth face. Unquestionably the safe load which can be transmitted by the gear teeth is all-important, but unfortunately the subject has been frequently regarded as entirely independent of any other feature of the reduction gear design. This is a mistaken view. The ultimate limit of pressure which the teeth can safely carry has not been determined, but the pressures at present in use among designers are only possible with the most accurate alignment. No comparison of tooth pressure is therefore reliable without careful consideration of the methods used to maintain the unit pressure within the limits for which the design was made. Faulty bearing design, inadequate support or improper couplings may be individually or collectively responsible for deranging the alignment, resulting in a concentration of the tooth load and often failure of the teeth. It is obvious, then, that merely to limit the unit tooth pressure to some fixed empirical figure for all gears in no way insures the safety of the teeth. On the other hand, anything which tends to maintain the alignment of the teeth and to prevent concentration of pressure is to be welcomed as a source of safety in the operation of the gearing. It is for this reason that the Melville-Macalpine invention of the I-beam support for the pinion bearings is so thoroughly justifying the claims made for it. The closer this mechanically-correct device is investigated, the more apparent becomes its most important function, namely, to maintain automatically a very uniform distribution of tooth pressure under the most severe distortions of the gear-case that can occur in the frailest hull. Its value in permitting higher unit loads than are customary on which have been termed "rigid bearing" gears is graphically illustrated in Fig. 1, subjoined. The curves of the rigid bearing dimensions have been compiled from recent marine practice in Great Britain. The floating frame figures are those used by the Westinghouse Electric and Manufacturing Company for marine work, and there are points indicated on this curve showing gears actually in service.

As previously referred to, the gear by permitting high turbine speed, much simplifies the turbine design. It enables a speed to be selected for the turbine appropriate for best economy. Furthermore, it inherently permits a design of increased reliability by virtue of sensibly reduced dimensions. The small high-speed geared turbines require few of the elaborate precautions in warming up and getting in service that must be practised with the large direct-connected turbines.

Gears may readily be arranged with two pinions for even the smallest single-screw steamer, permitting the employment of what are known as cross-compound turbines; that is, a high-pressure and a low-pressure turbine, the steam passing them in series. Piping is arranged that by the manipulation of valves the high-pressure turbine may exhaust direct to the condenser, or the high-pressure turbine be isolated and the low-pressure turbine receive high-pressure steam direct. Thus, generally speaking, no turbine or gear accident is likely to so incapacitate the machinery that the vessel cannot reach port at reduced speeds. There is one record of a 10½ knot steamer, which, on account of breakage of one pinion, crossed the Atlantic with the low-pressure turbine alone, obtaining speeds as high as 9 knots.

Fig. 1.


Pinion Diameter in Inches.
Tooth Pressure. Pounds per Inch of Face.
Rigid Bearing Gears - Merchant Service
Rigid Bearing Gears - Naval Vessel
Floating Frame Gears
22000 S.H.P. Gear
S.S. Gelasa, Main Ironsides, Overstrung Pinion, 2nd Reduction (Pinions)
U.S.S. Maryland
U.S.S. Hanley
S.S. Maui
U.S.S. Neptune
U.S.S. Arizona
S.S. Gelasa, Main Ironsides, Overstrung Pinion, 2nd Reduction (Pinions)
1500 S.H.P. Units, 1st Reduction Pinions
Axial Length of each Helix not exceeding Two Pinion Diameters for all Floating Frame Gears with the exception of those on the U.S.S. Neptune.
(5478.A)

The general arrangement of such an installation is shown in Fig. 2, annexed. Its reliability has much to commend it. This is not only due to the flexibility above referred to, but further due to the simplification of the turbines themselves. Each turbine only expands the steam corresponding to half the heat drop, and so has a much reduced number of turbine elements, smaller temperature range, and reduced length between bearings as compared with a complete expansion turbine, having similar economy. Both high and low-pressure turbines are provided with reversing elements arranged in a similarly compounded manner to the ahead elements, thus rendering manœuvring possibilities as complete with one turbine element operating as with both.

Of necessity the cross-compound turbine installation with its double pinion gear is more costly than the single complete expansion turbine, and with keen competition will not be installed unless shipowners recognise its manifest advantages. So far as the writer has observed, owners seem quite indifferent to the probable reliability of machinery so long as they secure insurance and the protection of the classification societies. The plea is therefore made by the author that underwriters, in collaboration with the classification societies, should discriminate in insurance rates between types of installations having manifestly differing degrees of reliability.

No doubt single-screw steamers will frequently be driven by single complete expansion turbines, at least for low powers. An example of a small-sized installation, 1,500 h.p., is shown in Fig. 3, page 43, and attention is called to some of its features. The double reduction gear elements are arranged one above the other with the high-speed pinion uppermost. This elevates the turbine axis and permits the condenser to be located immediately below the turbine, permitting the exhaust to issue from the underside of the turbine and pass vertically downwards to the condenser, much simplifying the removal of water. One end of the turbine is carried directly upon a bracket integral with the gear-case, the other by the exhaust outlet being set directly upon the condenser. The condenser is secured by its upper surface to seatings, eliminating disturbances to alignment on account of expansion of the condenser.

There appears to be much apprehension in the matter of the reliability of turbine-geared steamers, and if current rumour may be relied upon there have been many failures, which, with more careful design or by employing the best in the art, would seem to have been wholly unnecessary. To correct such an impression, Table II gives a list of all vessels equipped with the floating frame gear and Westinghouse turbines. The table states the date on which the vessel entered service, the power of the installation, and approximately the miles travelled up to the present time (September 1, 1918).

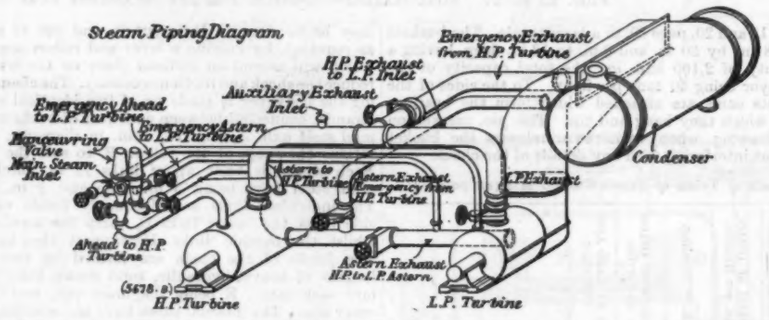
Some troubles have been experienced as are certain to occur with all kinds of machinery. Since there must be a large human element, footnotes are appended, plainly stating the charater of the troubles.

Note A.—U.S.S. Neptune.—This ship was equipped with two sets (twin screws) single reduction gears and turbines, the turbines having been largely experimental and were not successful. The gears, however, operated splendidly. The turbine machinery was then replaced, and inasmuch as a higher turbine speed was considered desirable, new gears involving a greater speed reduction were also installed at this time. The designed constants of the new gears were very high and are still much in advance of our present practice.

Considerable trouble was experienced due to the teeth abrading which was only overcome by the use of lard oil. Since that time, however, in November, 1915, no further trouble has been recorded, and the teeth at the last inspection were in good condition without any indication of wear.

Note B.—S.S. Maui.—This vessel was built at the Union Iron Works. Inasmuch as we were late in delivering the machinery, we were unable to carry out any tests on the gears in the works, and inasmuch as great store was set by the owners that nothing should go wrong on the maiden voyage, and as there was some uncertainty as to the excellence of the tooth surfaces, lard oil was employed as a lubricant for the first two voyages, after which mineral oil was substituted for the lard oil.

Fig. 2. ARRANGEMENT OF VALVES FOR CROSS COMPOUND INSTALLATION



The operation of the machinery was all that could be desired for eight voyages, at which time there was abrasion of the gears due to failure of the lubrication. This was discovered in Honolulu and the ship returned to San Francisco with nothing being done to the machinery except an attempt to clean the oiling system. The tooth surfaces smoothed up considerably during the voyage.

The gears were then transposed from one side to the other so as to make what had been the astern surfaces the ahead surfaces, so as to use uninjured tooth surfaces for ahead operation.

Again because of some uncertainty of the tooth surfaces lard oil was employed as a lubricant and the vessel entered in Government service, going to Chile for cargo and proceeding to Baltimore. During the voyage there was an accident to an oil cooler, admitting salt water to the system. The shipbuilder having provided no means of removing any water, the effect of the salt water on the lard oil was to turn it violently acid, which necessitated a complete overhauling of the machinery on its arrival in Baltimore.

On this being completed and on the trip from Baltimore to New York trouble was experienced with abrasion of the tooth surfaces due, it was believed, to an inferior quality of oil, together with further failure of the oil cooler, admitting enough water to the system to make an emulsion of approximately 30 per cent. A better oil was substituted and nothing was done to the tooth surfaces, the vessel having made one voyage to Europe and back with no trouble as far as the gears are concerned.

During this voyage trouble was experienced with one of the turbines, causing quite an extensive repair because of an obstruction in one of the oil passages to the thrust

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* Report, slightly abbreviated, read before the Society of Naval Architects and Marine Engineers, at Philadelphia, on November 14, 1918.

† *Vide London* ENGINEERING, dated September 17, 1909, May, 5, 12, 19, 26, and June 2, 9 and 16, 1916; Proceedings of Engineers' Society of Western Pennsylvania dated December 18, 1917; Institution of Naval Architects, London, March 29, 1917.

COAL-HANDLING PLANT AT THE COVENTRY CORPORATION ELECTRICITY WORKS.

MESSRS. ED. BENNIS AND CO., LIMITED, ENGINEERS, LITTLE HULTON, BOLTON.

(*For Description, see Page* 37.)

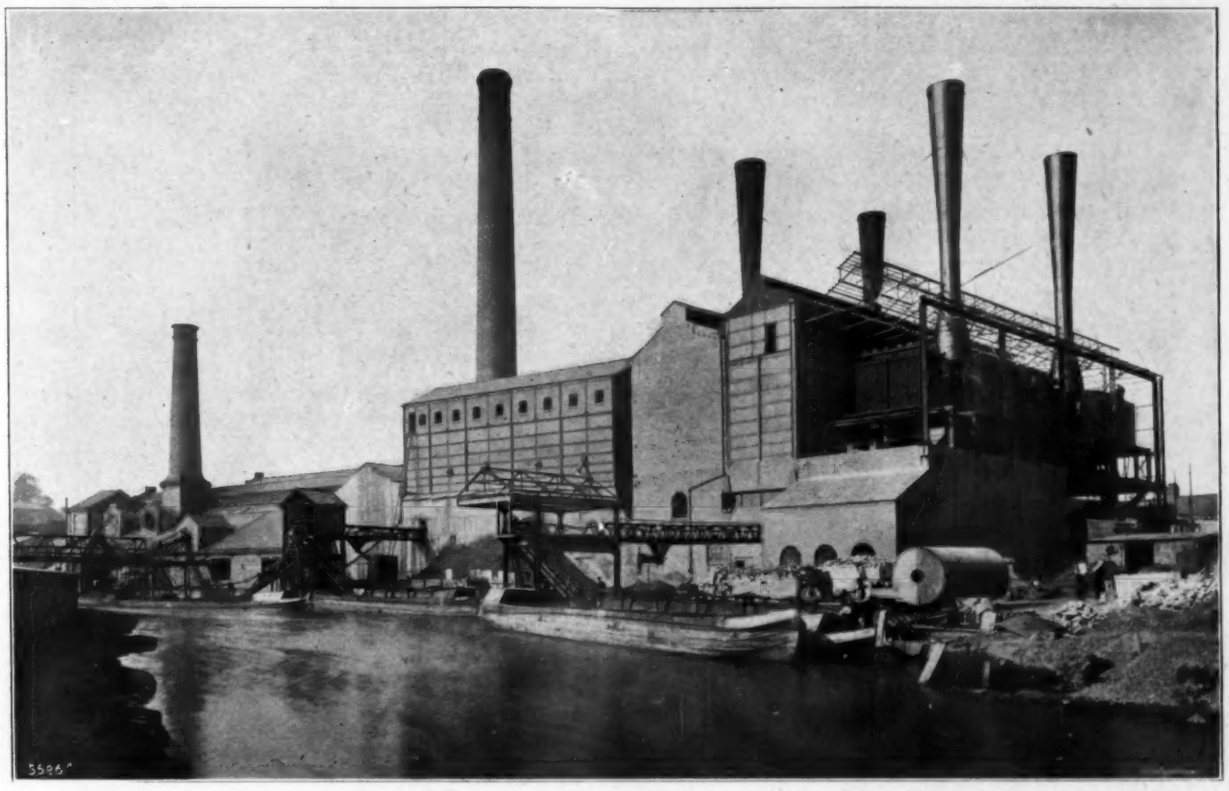


FIG. 1.

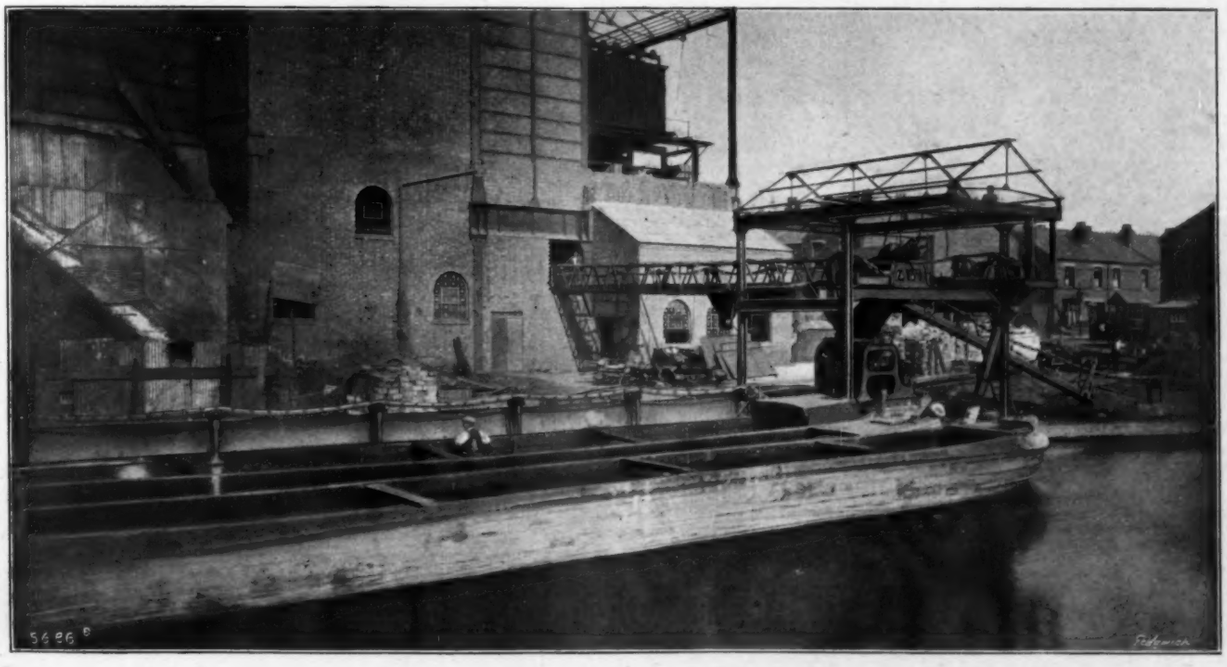


FIG. 2.

(*To face page* 38.)

COAL-HANDLING PLANT AT THE COVENTRY CORPORATION ELECTRICITY WORKS.

MESSRS. ED. BENNIS AND CO., LIMITED, ENGINEERS, LITTLE HULTON, BOLTON

(*For Description, see Page* 37.)

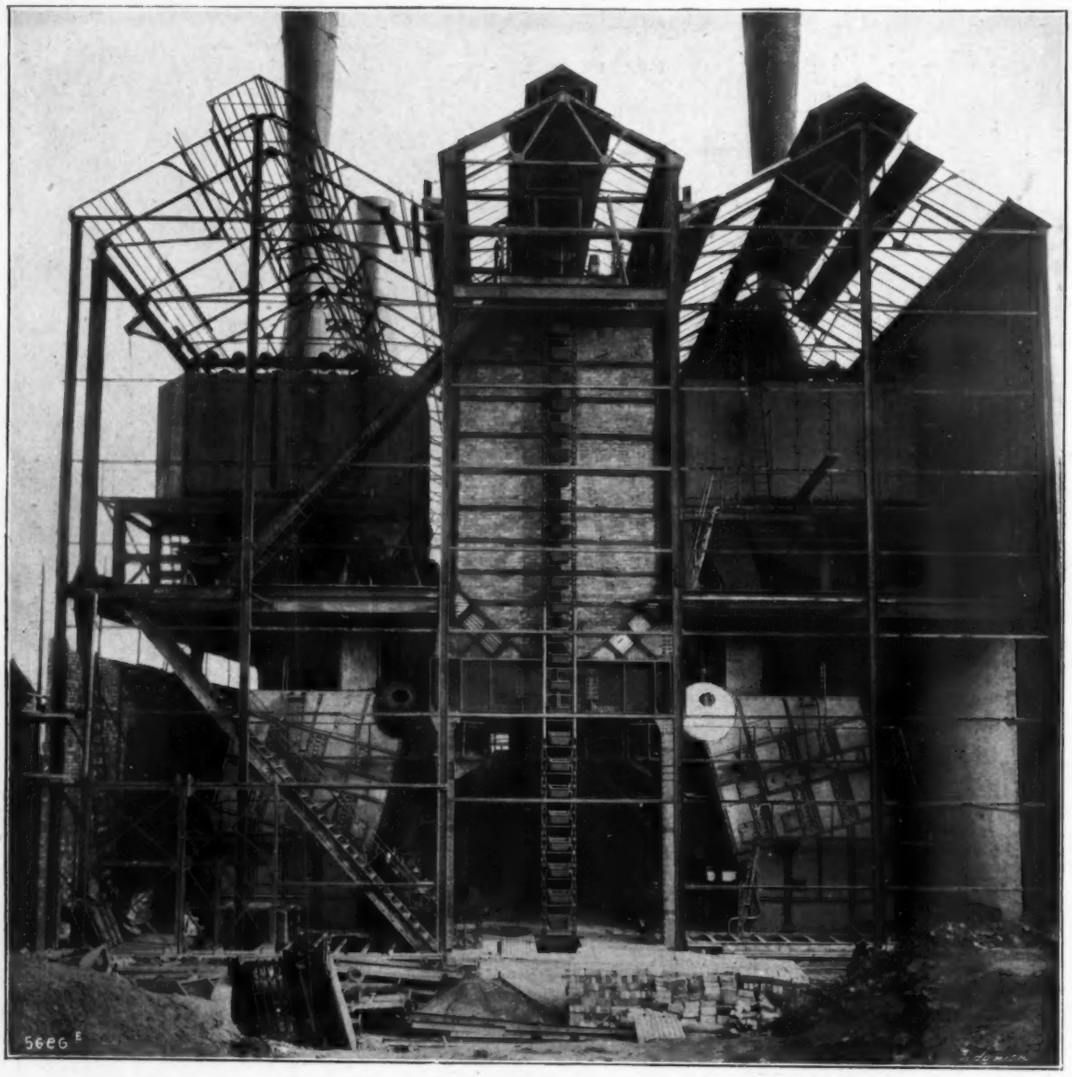


FIG. 9. THE LATEST BOILER-HOUSE.

FIG. 10. VIEW IN LATEST BOILER-HOUSE.

FIG. 11. UPPER RUN OF GRAVITY BUCKET CONVEYOR.

bearing of the turbine, causing the thrust bearing to fail; the turbine rotor moving endwise, completely wrecking the labyrinth packing between the ahead and astern elements and buckling the rotor.

Note C.—S.S. Golaa.—Norwegian oil tanker built by Chester Shipbuilding Company, and chartered by British Admiralty. Put in service July 6, 1917. Made three round trips to English ports. At present in coastwise trade between Port Arthur, Texas and Philadelphia or Bayonne. Towards end of last trip from Europe (February, 1918) some teeth on starboard high-speed pinion broke out. This gear was disconnected and ship made port, using low-pressure turbine only. Inspection showed break occurred on one helix, 3 in. from end of tooth face. There was no evidence of wear on any of the tooth faces, the undamaged portion of broken tooth face indicating uniform distribution of load. This fact and the position of fracture make certain accident was due to defective material.

Fig. 3. SINGLE TURBINE INSTALLATION (SUBMARINE BOAT)

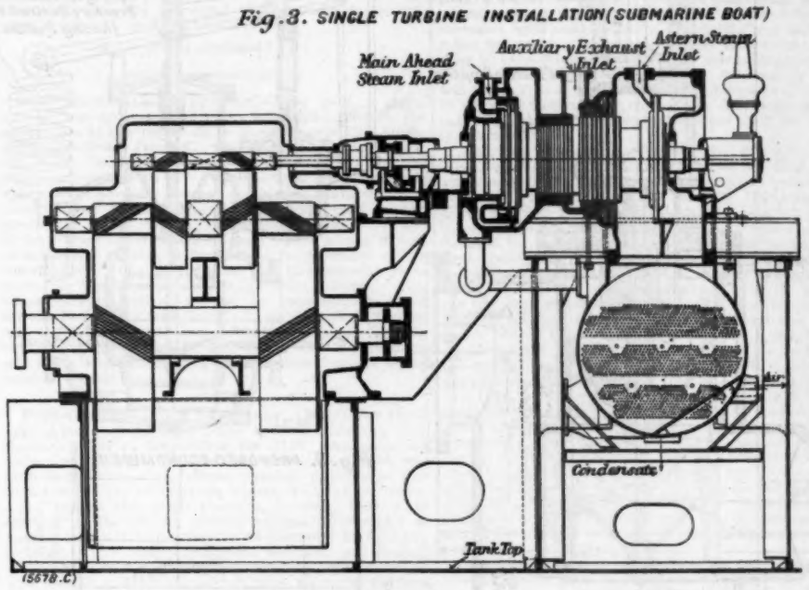


TABLE II.

Name of Ship.	Where Built.	S.H.P. per Ship.	Date in Service.	Miles Travelled (approx.).	Troubles in Service.	Remarks.
Melville ..	New York Shipbuilding Co.	4,000	11- 1-15	7,000	None	U.S. T.B.D., tender main gear only.
Neptune ..	Maryland Steel Co.	6,500	12- 1-15	128,000	See Note A	U.S. collier.
Malmanger ..	Chester Shipbuilding Co.	2,900	3- 8-17	2,500	None	Sunk 3-23-17.
Westwood ..	Ames Shipbuilding Co.	2,500	3-24-18	16,000	None	
Maui	Union Iron Works	10,000	4-17-17	60,000	See Note B	
Golaa	Chester Shipbuilding Co.	2,900	7- 6-17	36,000	See Note C	
Hisko	Chester Shipbuilding Co.	2,900	12- 4-17	25,000	None	
Coronado ..	Moore Shipbuilding Co.	2,400	1-29-18	27,000	None	
Yosemite ..	Moore Shipbuilding Co.	2,400	2- 2-18	27,000	None	
Westerley ..	Ames Shipbuilding and Dry Dock Co. ..	2,500	2-27-18	7,600	None	Sunk 4-29-18.
Sudbury ..	Chester Shipbuilding Co.	2,900	3- 5-18	15,000	See Note D	
West Eagle ..	Ames Shipbuilding and Dry Dock Co. ..	2,500	4-12-18	11,000	None	
Yellowstone ..	Moore Shipbuilding Co.	2,400	4-25-18	22,000	None	
Overbrook ..	Chester Shipbuilding Co.	2,900	4-30-18	16,000	None	
Oakland ..	Moore Shipbuilding Co.	2,750	5-30-18	12,000	None	
Accomac ..	Los Angeles Shipbuilding Co.	3,000	6- 6-18	12,000	None	
Avondale ..	Chester Shipbuilding Co.	2,900	6-23-18	6,000	See Note E	
Wakulla ..	Los Angeles Shipbuilding Co.	3,000	6-26-18	—	None	
West Ford ..	Ames Shipbuilding and Dry Dock Co. ..	2,750	6-30-18	8,000	See Note F	
Wampum ..	Los Angeles Shipbuilding Co.	3,000	7- 9-18	—	None	
Wassiac ..	Los Angeles Shipbuilding Co.	3,000	7-25-18	—	None	
Montrolite ..	Ames Shipbuilding and Dry Dock Co. ..	2,500	8-12-18	5,000	None	
West Galoc ..	Los Angeles Shipbuilding Co.	3,000	8-13-18	—	None	
West Gleata ..	Los Angeles Shipbuilding Co.	3,000	9- 5-18	—	None	
Polar Sea ..	Baltimore Dry Dock and Shipbuilding Co.	1,800	9- 6-18	—	None	
Phœnix ..	Chester Shipbuilding Co.	2,900	9- 7-18	—	None	
Pennsylvania	Newport News Shipbuilding Co.	3,200	Not known	Not known	None	U.S. battleship cruising gears only.
Arizona ..	New York Navy Yard	4,000	Not known	Not known	See Note G	" "
Mississippi ..	Newport News Shipbuilding Co.	3,000	Not known	Not known	None	" "
Henley ..	Re-engined at Philadelphia Navy Yard ..	14,000	Not known	Not known	None	U.S. T.B.D.
Mayrant ..	Re-engined at Philadelphia Navy Yard ..	13,500	Not known	Not known	None	U.S. T.B.D.

In August of this year the high-pressure turbine suffered injury as a result of improper setting of the turbine thrust bearing. Shortly thereafter an accident occurred to the pinion which replaced the one originally defective. The character of the broken tooth was similar to the previous one. The broken parts have not yet been received to enable a careful examination of the material to be made.

Note D.—S.S. Sudbury.—An American freighter built by the Chester Shipbuilding Company for the Shawmut Steamship Company. It is at present being operated by the United States Naval Overseas Transportation Service. A few days after leaving France on return half of maiden voyage, some teeth broke out of starboard high-speed pinion. This gear was disconnected and ship returned to New York, using low-pressure turbine only, with which 9 knots was attained, the designed full speed being 10½ knots.

On arrival at port, inspection showed no wear, the tooth load having been well distributd on all tooth faces. Several teeth were cracked. Subsequent examination of steel indicates defective material, most probably due to faulty heat treatment, the fracture indicating the steel had been burned. This was confirmed by discovery that some teeth in port high-speed pinion were also cracked, although no failure occurred in service. Both pinions were forged from the same billet and treated at the same time. These pinions are similar as to material and design with 25 other pinions now in successful operation.

Note E.—S.S. Avondale.—An American oil tanker, built by the Chester Shipbuilding Company, and being operated by the Pan-American Oil Company for the United States Shipping Board. Just as ship was leaving Philadelphia for trial trip a heavy blade rub was heard in high-pressure turbine. Inspection indicated defective workmanship. Some of the rotating blades were loose as a result of having been improperly put in. The spindle was rebladed and ship proceeded satisfactorily from Philadelphia to New York. This turbine is a counterpart of 12 others now in successful operation on various ships.

Note F.—S.S. West Ford.—This vessel left Seattle at 5 p.m. on July 14, 1918, on her maiden voyage to an Atlantic port. Seven hours out from Seattle, oil commenced foaming out from the turbine, running over the engine-room gratings. The chief engineer was called and, instead of investigating the reason for augmentation of the oil, he was content to pump 200 gallons to a reserve tank. Later the same thing occurred, oil again running out on the gratings, and later still at 2.14 a.m., the high-pressure turbine commenced vibrating so badly that it interfered with their lighting system. They shut down to remedy the matter of the lighting system, and on trying to start the turbine it required 125 lb. initial pressure to revolve it. Serious vibration was again in evidence, so the chief decided to do what he termed "crank up on the thrust." It was impracticable to anchor, so they returned to Port Townsend at 40 r.p.m. They then made an observation of the oil in the drain tank, and on removing the cap the oil squirted to the roof of the shaft alley. It was later discovered an oil cooler tube had split, admitting large quantities of salt water to the oil system.

Instructions had been given that the level of the oil in the drain tank should be regularly observed, and it is incomprehensible that it was not at once obvious that something was getting in the oil system from some exterior source. Merely looking at the oil would have determined this was salt water. Then all that would have been necessary was to shut off the water service to the cooler and separate the relatively small quantity of salt water from the gravity tank, and there need have been no interruption whatsoever. The result of such neglect was for the bearings, for want of lubrication, to let the rotor down, causing considerable injury to the turbine.

Note G.—U.S.S. Arizona.—On a voyage from Cuba to the United States the teeth of one of the crusing gears scored. Subsequent investigation showed that the oil pumps had stopped and the supply to the gears had failed. The teeth were dressed up and no further trouble has been experienced.

As in land installations, the overall economic performance is not dependent on the prime mover alone. High performance is not to be secured without care being bestowed on all the ancillary apparatus, attention to matters of heat balance with the feed-water heater, condensing apparatus capable of performing with a close approach to the ideal, &c.

Large size land turbines have been built which deliver to the shaft not less than about 80 per cent. of the theoretical energy available from the steam expanding between the limits specified, so that further improvements in the turbine itself will not materially raise this efficiency. Further improvement in economy must be looked for from causes other than the prime mover itself. This is a subject of the greatest importance in view of the rapidly increasing cost of fuel, and it justifies considerably more capital expenditure for economisers and other such apparatus which will reduce fuel cost.

The engineer of our large central stations is subject to keen competition and is confronted almost solely with the problem of producing reliable energy for the least cost, including fixed charges. He has before him daily statements showing his overall power costs with a high degree of accuracy, resulting in considerable success on his part in the production of low power costs.

It is therefore not unreasonable that the marine engineer might look to the central station engineer for advancement from some of the latter's best practice. It is, of course, understood that complete standby machinery is not available for the marine engineer, neither can the superintending engineer direct those in immediate charge of the machinery by frequent visits. Hence there is the more urgent call for the greatest reliability and simplicity of the marine installation; though, after all, perhaps not more than that which the central stations have in our big cities. An interruption to service, however brief, is regarded most seriously.

Feed-Water Heating Systems.—It is common practice on shipboard to provide a closed or tubular heater to which is led the exhaust steam from the auxiliary machinery, which latter exhausts at a pressure between 5 lb. and 10 lb. gauge. The exhaust system is provided with a connection to let any proportion of this steam to the condenser. Sometimes again there is a hand valve, permitting any surplus of this steam to be taken to a low-pressure stage of the turbine, all of which calls for hand manipulation where the conditions are sometimes quite variable, owing to more or less intermittent operation of the feed pump. Sometimes the connection to the condenser is provided with a spring-loaded valve so that when the exhaust pressure reaches a predetermined pressure, higher than that within the condenser, steam may pass to the condenser. The construction of the valves usually employed is such that the higher the pressure in the condenser, the higher is the pressure at which the steam will pass to the condenser, which is, of course, undesirable. A system which will automatically maintain a predetermined temperature in the feed heater at all times, bleeding the main turbine for this purpose, at high powers if necessary, and at the same time automatically permit any surplus steam not condensed in the feed-water heater to do useful work in the turbine, is much to be desired.

Heat balance systems have for some time been available for land purposes, there being provided automatic valves so that whenever there is a surplus of auxiliary exhaust steam this surplus may pass through a low-pressure stage of the turbine, doing work therein at the rate of 20 lb. to 22 lb. per horse-power. Other types of valves are available for land installations which will not only take surplus steam into the turbine at times of light loads on the main unit at which time the auxiliaries will obviously furnish too much exhaust steam; but, on the other hand, they are arranged to deliver steam from the turbine to the feed-water heater at times of heavy loads when the stage pressures in the turbine are relatively high and there is a deficiency of steam for feed-water heating. The latter should particularly find a place on war vessels which are required to operate for long periods at different speeds, where there is a widely varying ratio of steam used by the auxiliary machinery to that used by the main turbines. In merchant vessels

this ratio is more nearly constant, but nevertheless careful study to the end of obtaining a complete heat balance will be advantageous. Details of the two forms of valves above described are shown in Fig. 4 and Fig. 5, subjoined.

The valve shown in Fig. 4 is intended for cases where there is never a deficiency of auxiliary exhaust steam for feed heating. It comprises a piston having atmospheric pressure above it, and the auxiliary exhaust steam below. When the auxiliary exhaust steam pressure rises a sufficient amount above the pressure of the atmosphere to raise the piston, steam may pass to the turbine. Air leakage into the turbine is entirely precluded by ample steam seal around the piston furnished by the auxiliary exhaust steam. The piston may be loaded to any feed-heater pressure desired. The upper cylinder is to forcibly close the valve in the event of the turbine over speeding.

The modification of this valve shown in Fig. 5 is adaptable where there are at times a deficiency of auxiliary exhaust steam. Any time the stage pressure in the turbine is greater than that in the heater, the lower piston will raise, permitting passage of steam from the turbine to the heater at the same time, when required, permitting flow to the turbine as in the case of the valve shown in Fig. 9.

It sometimes occurs that the turbine is subjected to such overloads that a stage of the turbine selected to give the desired heater pressure at moderate loads would be far too high for the heater at overloads. In this instance the modification shown in Fig. 6, subjoined, may be employed which limits the pressure in the heating system in accordance with the spring adjustment, regardless of how high may be the pressure in the turbine.

It is the universal practice to employ closed tubular heaters in marine work, while in land work what is known as the open heater is the rule. With the advent of turbine-driven auxiliaries and electrically-operated winches, &c., the auxiliary exhaust may be uncontaminated with oil, permitting the employment of an open heater for shipboard use, and a more complete separation of air from the feed water. As this type of heater contains no tubes, the heating steam mixes with the feed water, as in a jet condenser, so its cost is materially less. Frequently these heaters are open to the atmosphere, and hence their name, but when working in connection with the heat balance system they must obviously have no open outlet, merely a provision for the separation of air, and a relief valve for safety. Such a type of feed heater eliminates need of a separate feed tank and must be located some feet above the feed pumps to preclude the latter being vapour bound because of pumping water near the temperature of evaporation.

Steam Pressures.—The attention of central station engineers at the present time is being directed to employing higher boiler pressures, viz., pressures as high as 600 lb. To-day 200 lb. pressure and 200 deg. F. superheat are regarded as a more or less everyday operating condition for large plants. Steam generated at 600 lb. pressure, having exactly the same heat content as that contained in 200 lb. pressure and 200 deg. F. superheat will have a superheat of approximately 128 deg. F. This, expanded to 29 in. vacuum, is theoretically capable of giving 13 per cent. more energy than when generated at 200 lb. and expanded to the same vacuum. Doubtless, when operating under the high-pressure conditions, the turbine will be of lower efficiency. The high-pressure element will be less efficient on account of the great density and the small volume of the steam, and on the other hand the low-pressure elements will be less efficient because of the great amount of water precipitated by the steam expansion from the high pressure, introducing a brake in the turbine. However, it is reasonable to suppose that the turbine will avail itself of at least 50 per cent. of this 13 per cent. possibility, producing a net saving of 6 per cent. or 7 per cent. What may be expected to be derived from higher pressures is exhibited in Figs. 7 and 8, on the present page, plotted for various pressures.

Economisers.—So far as the author is aware, economisers have not been employed in marine installations. It would seem that their capital cost would be well warranted for the case of express steamers operating always at their maximum speed. In the case of 250 lb.

Fig. 4. HEAT BALANCE VALVE (FOR FLOW TO TURBINE ONLY).

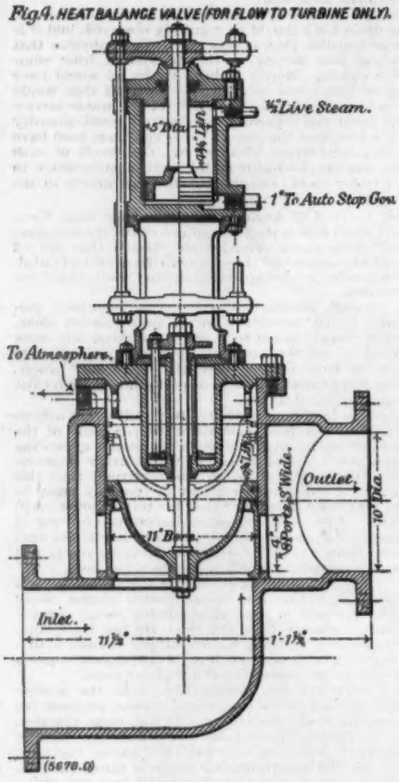


Fig. 5. HEAT BALANCE VALVE (FOR FLOW TO & FROM TURBINE).

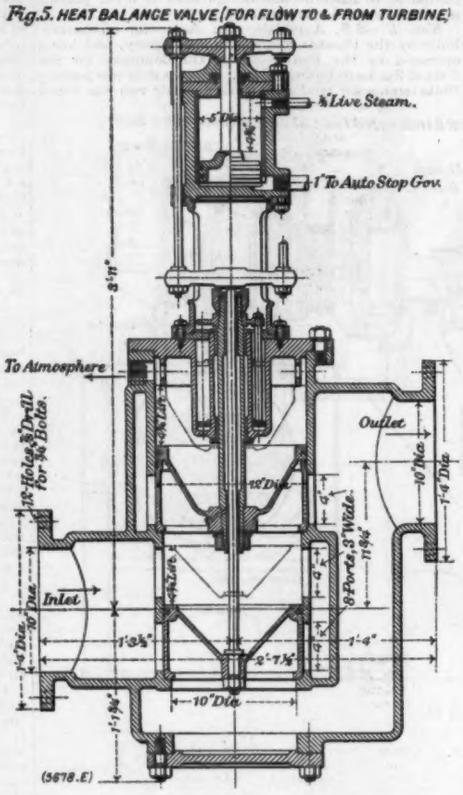


Fig. 6. HEAT BALANCE VALVE (FOR FLOW TO & FROM TURBINE WITH PRESSURE LIMITING DEVICE).

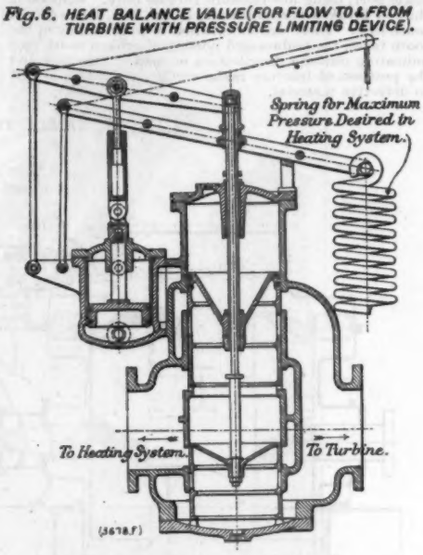


Fig. 9. PROPOSED ECONOMIZER.

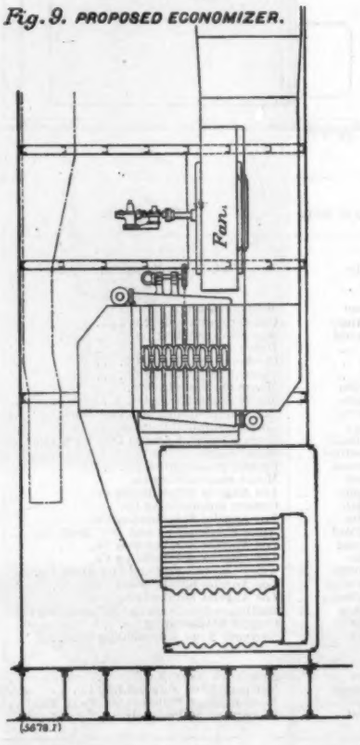


Fig. 7. 60,000 K.W. 3 CYL. TURBO UNIT 1800 & 1200 R.P.M. COMPARATIVE PERFORMANCE AT 45,000 K.W. WHEN SUPPLIED WITH STEAM HAVING TOTAL HEAT (ABOVE WATER AT 32°F) OF 1280-1300 & 1320 B.T.U. PER POUND AT VARIOUS PRESSURES FROM 200 LBS. PER Sq. In. TO 600 LBS. PER Sq. In. ABS.

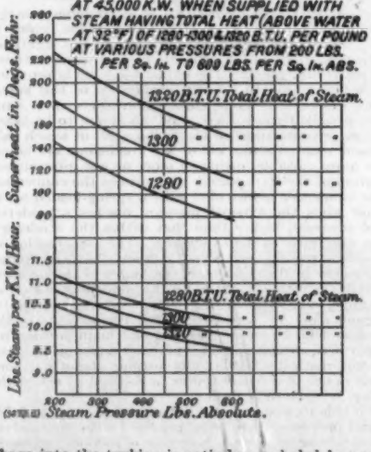
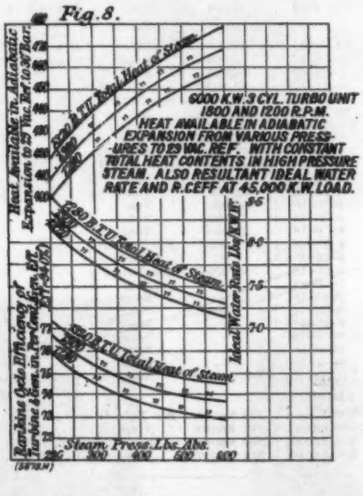


Fig. 8.


6000 K.W. 3 CYL. TURBO UNIT 1800 AND 1200 R.P.M.
HEAT AVAILABLE IN ADIABATIC EXPANSION FROM VARIOUS PRESSURES TO 29 VAC. REF. WITH CONSTANT TOTAL HEAT CONTENTS IN HIGH PRESSURE STEAM. ALSO RESULTANT IDEAL WATER RATE AND R. CEFF AT 45,000 K.W. LOAD.
Heat Available in Adiabatic Expansion to 29 Vac. Ref. to 32° Bar.
1320 B.T.U. Total Heat of Steam
1300 " " "
1290 " " "
1280 B.T.U. Total Heat of Steam
1260 B.T.U. Total Heat of Steam
Ideal Water Rate in Lbs. K.W.H.
Steam Press. Lbs. Abs.
(5678.H)

gauge steam pressure there is a 16 per cent. saving in the work of the boiler by a feed temperature of 375 deg. F. as compared with 212 deg. F. To this gain there must be made a deduction of the energy expended by the induced-draught fans and the scrapers for the economiser surfaces. A net gain of 10 per cent. should be readily realised. Their installation would seem to present no particular difficulty as is shown in Fig. 9, page 44.

Superheat.—With the old direct-connected turbines, superheat has never been recommended, and wisely so considering their immense structure. Even with the much smaller high-speed geared turbines as high superheat as is desirable in land installations may not be practicable at sea on account of the rapid stopping, starting, &c., necessary for quick manœuvring, which may cause uneven heating and cooling. In the author's opinion superheats as high as 100 deg. F. should present no operating difficulty whatsoever with well designed high-speed turbines. 100 deg. F. superheat will affect the steam consumption not less than 8 per cent. as compared with dry saturated steam, probably saving some 4 per cent. or 5 per cent. in fuel.

(*To be continued.*)

RAW MATERIALS IN NORWAY.—Last year a commission was appointed to make investigations into the production of raw materials in Norway, says *The Anglo-Norwegian Trade Journal*. On behalf of the commission Mr. V. M. Goldschmidt has now given a report of the work. According to this report several such materials can be produced in Norway, including plumbago and phosphates. Special attention has been paid to the production of fire-resisting materials. The development of the Norwegian smelting industry will to a large extent be facilitated if these materials can be produced within the country. The information Mr. Goldschmidt gives regarding dolomite is of the greatest interest. This commodity is of great use in constructing dams for the Norwegian waterfalls. It appears that Norway has the largest and best dolomite fields in Europe, containing about 300,000,000 tons. The Government will now, it is understood, exploit these deposits on an extensive scale.

POST OFFICE LONDON DIRECTORY, 1919.—The 120th annual issue of the Post Office London Directory with County Suburbs, the edition for 1919, was issued on December 20, as early as on the preceding occasion, and notwithstanding the greatest possible difficulties, due to the war. The proprietors, Messrs. Kelly's Directories, Ltd., 182 to 184, High Holborn, London, W.C. 1, in sending us the present edition express their regret at having found it impracticable to continue as formerly publishing the Directory in two volumes, one dealing with London only and the other with the London suburbs. The present edition consists of three volumes, the first dealing with the streets section, the banking, official and court directories, etc.; the second with the commercial and trades directories; the third with the London county suburbs. This alteration, they add, has been solely due to the inability of the binders to deal with volumes extending to so many thousands of pages, a very large portion of their staff having been required for military service and national work. In our opinion, this will not detract in any way from the value of the publication, rather to the contrary; the three volumes will be found handier than the former two. Apart from this innovation, the Directory retains all its well known features and will retain also all its usefulness for reference purposes in the present period of reconstruction and trade activity. The armistice was, probably, signed too late in the year to enable the publishers to add to the plan the outlines of the principal monuments of London which were erased during the war. The price for the complete edition, including Vol. III dealing with the suburbs, is 64s.—or for Vols. I and II only 48s.

MOLYBDENUM WITHIN THE EMPIRE.—Molybdenum generally occurs in Nature in combination with sulphur, oxygen, or lead. Of commercial importance are the sulphide MoS_2 (called molybdenite), a soft lead-grey mineral of metallic lustre, resembling graphite, but much heavier, and the yellow wulfenite, a lead molybdate, usually containing a little copper, vanadium, iron and calcium. According to a contribution to the Journal of the Society of Chemical Industry (December 15, 1918), by Sydney J. Johnstone, of the Imperial Institute, the world's production of molybdenum ore concentrates rose in the years 1913 to 1916 from 148 tons to 495 tons. Queensland producing, in 1916, 81 tons (111 tons in 1917), New South Wales 54 (70) tons, Canada 74 (121) tons, Norway 100 tons, and the United States 90 tons in 1915. The figures given show that Canada and the United States are, with Norway, becoming the most important sources of the metal. Before the war, when high-grade minerals were chiefly worked, Australia ranked first among the molybdenum-producing countries: in addition to Queensland and New South Wales, Victoria and South Australia contain promising deposits, beds have recently been discovered also in Tasmania and in New Zealand. Rich ore occurrences are rare, and a large portion of the molybdenum comes from tungsten and bismuth mines, also from tin mines. The largest company in Canada is the Canadian Wood Molybdenite Company, of Quoyon; but the Dominion Molybdenite Company and other concerns have come to the front. South Africa and South-West Africa can supply molybdenite; there has been some output of these ores in India since 1916, and although many occurrences of the metal are so far undeveloped, the British Empire is certainly well stocked in this respect.

THE FUTURE OF UNITED STATES SHIPBUILDING.

WE take the following extracts from the address of Lieutenant-Commander Stevenson Taylor, U.S.N.R.F., president of the Society of Naval Architects and Marine Engineers, at its annual meeting, held in Philadelphia, on Thursday, November 14, 1918.

The entire merchant tonnage of the world in 1916 did not exceed 50,000,000 gross tons.* Of this there has certainly been destroyed by submarines and casualties not less than 14,000,000 gross tons, leaving of the original quantity not over 36,000,000 gross tons. During 1917 and 1918 there will have been built at most 5,000,000 gross tons, making a total of available tonnage only 41,000,000 gross tons. Following the normal increase per annum there should be available at the beginning of 1919 at least 55,000,000 gross tons. From this statement it appears that there will be at the close of the year 1918, a deficit of at least 14,000,000 gross tons, without taking note of the depreciation and repairs which the excessive hard usage of ships during the war will have made necessary. It is not intended that these figures shall be considered exact, but they are sufficiently so to demonstrate the great necessity still existing for ships; and further to show that our own shipyards must still be urged to their utmost capacity in order that the now important American merchant marine shall be upheld in the future.

American Shipyard Production.—In the year ended June 30, 1908, the entire production of our (U.S.) shipyards was 614,000 gross tons, the greatest previous to 1915; but in the year ended June 30, 1915, the production fell to 225,000 gross tons, the smallest output in seventeen years. In 1916, there came an enormous demand for ships not only from our own citizens, but from foreigners as well. When the United States entered the war in April, 1917, it became apparent that there was hardly a more important element for winning the war than ships, and the United States Government, through the agencies of its Shipping Board and Emergency Fleet Corporation, immediately proceeded to encourage the building of many new yards as well as the enlarging of the old yards with the result that there are now about 200 shipyards, instead of 66 as in November, 1916. During 1917 there was an output of 800,000 gross tons and the output for 1918 will apparently be about 2,000,000 gross tons actually delivered and officially numbered. The increase in our registered shipping during the fiscal year ended June 30, 1918, was 1,053,481 gross tons, more than double that of any previous year and something over the total increases for the first three years of the war combined. At the end of this year there will be over 10,000,000 gross tons of shipping under the American flag, or nearly double the amount of three years ago.

New Methods.—The demands upon our facilities for furnishing the usual materials for ships and the lack of men capable of building ships in the usual manner, combined with the extraordinary need of ships, and more ships, to carry on the war, has led to experimenting in building large vessels of other than the usual wood and steel materials. The successful use abroad of moderate-sized boats built of concrete reinforced with steel has led us to go much further, resulting in the building of the Faith, a concrete ship of about 3,000 gross tons, and the placing by the Emergency Fleet Corporation of contracts for 42 concrete ships totalling about 200,000 gross tons. The details, advantages and disadvantages of building reinforced concrete ships have received a great deal of attention from the officials of the Emergency Fleet Corporation, and it is fair to presume that their investigation has warranted the contracting for four ships of this class of about 2,500 gross tons and 38 ships of about 5,000 gross tons each. This same question has been also under examination and discussion in Great Britain, and naturally personal designs and views differ materially. Having had no experience in concrete construction and noting the different proportions of steel in several designs and acknowledged contrasts in carrying capacity and speed with like power, I feel that the concrete sea-going ship is still an experiment and that it is quite possible that the emergency which promotes the building of these ships will have vanished before those contracted for will have performed much service.

Another novelty even more novel than the concrete ship is the proposed electrically-welded ship which has now been under consideration for several months. There has been a vessel (perhaps more than one) manufactured on this plan in Great Britain, but the barge is so small that nothing is proved so far as the building of ocean-going ships is concerned. Electric welding certainly has proved successful in many places and under peculiar conditions, so that the proposed construction of a full-size section of a large cargo steamer for complete tests of the method is both interesting and satisfactory.

The fabricated cargo ship and the shipyards for building same will also receive at this meeting well deserved notice, for nowhere has the broad vision of men along these lines been exercised more than in our own country.

Records.—Records of various processes have from time to time been noted. The number of frames erected in a day, the number of rivets driven; the few days that have elapsed between the laying of the keel and the launching and again between the launching and the trial trip; the lineal amount of caulking both on wood and steel ships, and so on, to absurdity. We venture to say that in every instance of these special records there has been special preparation that the records shall be made. The fact remains that the general results attained in the long run are not in accordance with the records, and it were better to remember that 400 rivets for every gang for a day's work is a more satisfactory performance than an occasional 1,000 or more rivets. It is, however, to be said in justice, that the performance of finishing a ship in an unusual short time and the performance repeated over and over as has been done, is worthy of the highest commendation.

The Future.—The one great problem for us to consider is that of the future of our merchant marine and what is to be done with it. You who are owners of ships and shipyards, and you who design and construct ships cannot be indifferent to this question. There are at present in service, as has been stated, 10,000,000 gross tons of American merchant ships, double the amount three years ago, and there is a capacity in our yards for building in addition to the ships for the navy at least 3,000,000 gross tons per annum. Some of these yards, of course, build wood ships which will be useful coastwise if not across the seas. When the war is really over shall we as a nation supinely as in the past permit the other nations of the world to carry our entire commerce overseas? It is incredible that any administration of the United States Government shall thus sacrifice the great funds and efforts, individual and collective, that have been expended in the past two years to build up facilities, to educate men, and women too, in order that we may have and operate ships of our own; and if there are laws upon our statute books that prevent our reasonable operation of ships, they must be amended; if our loading, unloading and other port facilities are not what they should be, they must be changed; if there is anything which interferes with our progress upon the seas, it must be removed, and if there is anything yet lacking to advance this progress, even government ownership, or private ownership aided by a judicious government, it must be developed not for the advantage of any section or coast, but for the needs and advantage of our whole nation. I am quite aware that these are most general statements and that I have suggested no special plan for bringing about that which is so much to be desired. Frankly, I must say that the questions involved are too much for one man, and the result desired can only be accomplished by proper co-ordination of those out of whose experience may be determined the best course to follow.

I recall at this point the wild statements made early in 1917 as to our promised ship production. No one familiar with our business was deceived; but when the summer of that year had passed, and numerous yards had been established and the great number of fabricated ships had been contracted for, our hopes were raised that there would be, during this year 1918, a production of ships in our yards considerably greater than ever before produced in one year in any other single nation. We have not realised these fond hopes, but I ask you to consider what has been done in the country besides building ships.

Think of the enormous tasks accomplished in the past twenty months, three of which were the hardest winter months ever known in this country. Think of the cantonments and camps built for soldiers, sailors and aviators; the raising of an army of 3,000,000 men and the manufacturing of clothes, guns, artillery, munitions and supplies for such army; the despatching "over there" with the aid of our allies of an army of 2,000,000 men, and all of the impediments of war besides; the further extraordinary work done by the several aid associations, the Red Cross and others, and with it all, the raising of a fourth Liberty loan of six billions dollars in three weeks, following the raising of nine billions in the other loans and every one of the loans oversubscribed.

Think of these accomplishments, far greater than ever before performed by any nation in the same period of time, and you will conclude that building the yards and 2,000,000 gross tons of ships in twelve months, while all of the former programme was also being carried on, is an additional accomplishment worthy of notice and praise.

SPECIFIC AND ATOMIC HEAT OF PLATINUM.—In our issue of July 19, 1918, on page 73, we noticed the recent researches of A. G. Worthing on the atomic heats of incandescent tungsten and carbon. In accordance with modern theories the atomic heat, expressed in calories per gram atom per deg. C. should rise from the value 0 at absolute zero to the limiting value 5·95. This value refers to C v, the atomic heat of constant volume. Actually the determinations have to be conducted at constant pressure and corrections have to be made from the (higher) values of the C p observed to arrive at the desired C v value. Worthing found for the C v of tungsten at 2,400 deg. C. absolute the value 7·35 (instead of 5·95), and there were previous observations on other metals showing that the limit value was exceeded in some cases already at the relatively low temperature of 700 deg. C. The full particulars of Worthing's research have meanwhile been published in *The Physical Review* of September, 1918 (pages 199 to 225). The December issue of the same journal brings an account of an investigation by Walter P. White, of the Carnegie Institution at Washington, on the Specific Heat of Platinum. The value of this constant is of considerable interest, and it was known that the early determinations by Pouillet (1836) and Violle (1877) needed corrections. Experimenting with a very pure platinum from Heraeus (thermocouple wire) and a less pure metal from the same source White finds values for the specific heat of platinum between 100 deg. and 1,300 deg. C., which are in good agreement with those of Gaede, Plato, Corbino and others, and which show that for platinum also the atomic heat at high temperatures is higher (6·844) than the limit value assumed.

*The word tons in this address means registered gross tons. A deadweight ton is approximately 1½ gross tons.

REINFORCED-CONCRETE STEAMER "ARMISTICE."

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, LIMITED, BARROW-IN-FURNESS.

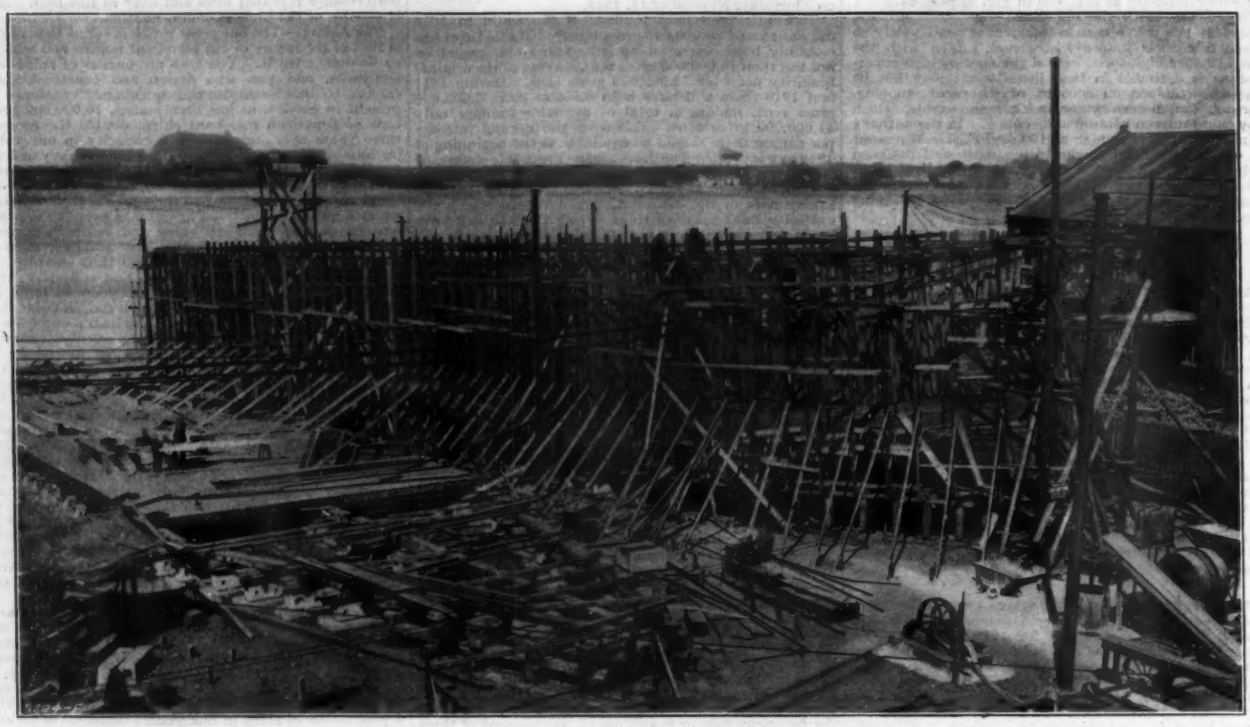


FIG. 1. SHUTTERING FOR FRAMES AND PART OF SHELL.

THE launch of the first large self-propelled sea-going reinforced-concrete vessel to be built in Great Britain—the Armistice—took place at the Ferro-Concrete Ship Construction Company's yard, Barrow-in-Furness, on Tuesday last. This company were amongst the pioneers in ferro-concrete ship construction in this country, and on their own initiative ventured on sea-going vessels of larger size than had been attempted in this country.

Owing to the enormous losses sustained during the war, the question of increasing tonnage occupied the minds of a great number of our shipowners and shipbuilders. For years before the war, the construction of vessels in ferro-concrete had been talked about, and a few ships, although quite small in size, were being used with success. It was only, however, under the great need for tonnage, and when the Norwegians had successfully launched some small reinforced-concrete vessels, that British firms seriously considered the problem. A company was formed, including shipbuilders and ship owners, to promote the construction of a number of small reinforced-concrete cargo vessels, in a patriotic endeavour to overcome the steel shortage, but they realised the experimental nature of the proposal. The use of ferro-concrete as a building medium was little known to shipbuilders, so that it was considered desirable to obtain the assistance of Mouchel and Partners, the Hennebique reinforced-concrete engineers, to advise and co-operate in matters relating to the actual ferro-concrete construction of the vessels.

Under these conditions, a design was got out for a vessel of about 1,150 tons deadweight, and the Armistice, just launched, is the first of the class to be constructed. An interesting paper was read at the Institution of Naval Architects,* by Mr. T. G. Owens Thurston, Managing Director of the Company, in which he described the design, and gave details of the vessel, and it is only necessary here to treat the subject broadly. The principal dimensions are as follow :—

	Ft.	In.
Length between perpendiculars	205	0
Breadth, moulded	32	0
Depth, moulded	19	6
Draught, when loaded	15	6
Indicated horse-power (about)	400.	
Speed (about)	7½ knots.	

* See ENGINEERING, vol. cv, pages 335 and 359.

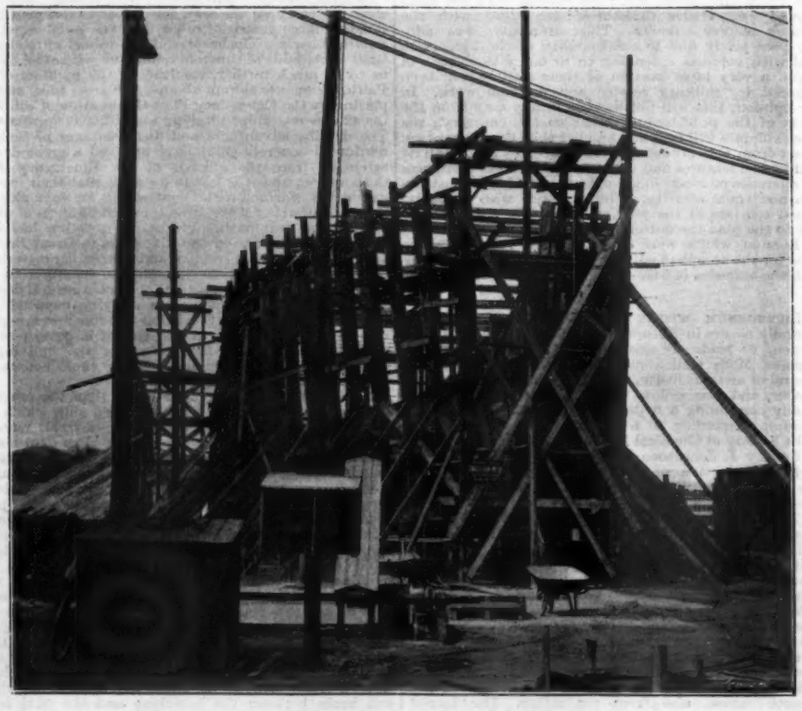


FIG. 2. VIEW OF SHUTTERING AT THE BOW.

The vessel is a single-deck cargo steamer, with two holds, the forward one having a total capacity of about 42,000 cub. ft., the after one a capacity of about 21,000 cub. ft. The vessel has been built to Lloyd's and Board of Trade requirements, and is classed A.1 experimental. The vessel is rigged as a two-masted fore and aft schooner of the single-deck type, and has straight stem, and elliptical stern. A short full poop,

REINFORCED-CONCRETE STEAMER "ARMISTICE."

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, LIMITED, BARROW-IN-FURNESS.

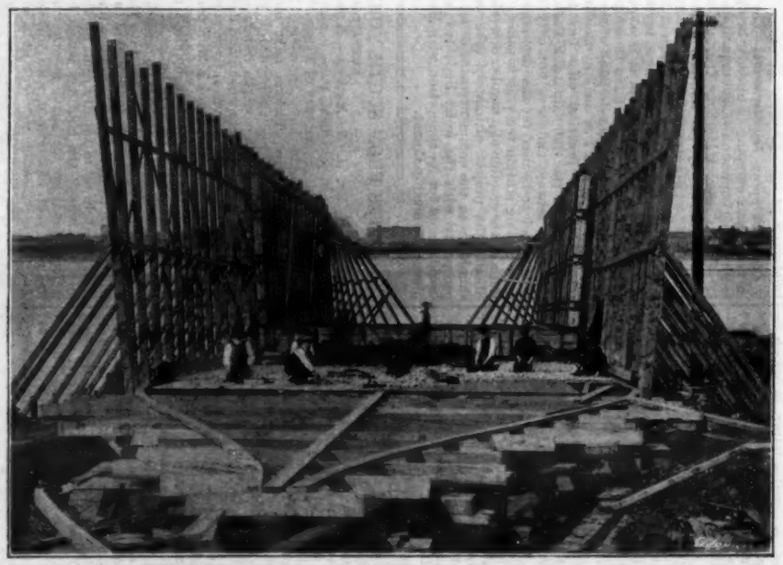


FIG. 3. CONCRETING OF DOUBLE-BOTTOM FRAMES.

FIG. 4. FRAME-SHUTTERING WITH REINFORCEMENT BARS IN POSITION.

FIG. 5. THE FRAME-SHUTTERING OF THE "ARMISTICE" AND HER SISTER SHIP.

FIG. 6. VIEW OF REINFORCED FRAMING AND DOUBLE BOTTOM.

37 ft. long, and a top-gallant forecastle 24 ft. long. The entire hull of the vessel, including the poop, bridge-house and forecastle, &c., is constructed of reinforced concrete. The accommodation for the captain, officers and engineers is fitted in the poop, and the accommodation for the crew in the forecastle. A deck-house is built adjoining the boiler casing over chart-house, and a wireless room, with a steering house over, forming the support for a flying bridge and wheel-house.

The machinery and boilers are placed aft. There are two cylindrical boilers, of 9 ft. 6 in. diameter by 9 ft. long, constructed to work to a pressure of 140 lb. per square inch. The engines are of the compound surface condensing type, having cylinders 15½ in. and 33 in. by 24-in. stroke. Large coal bunkers are built at the fore end of the engine room, extending over the full width of the vessel, and having a capacity of 50 tons.

A steam windlass is supplied and fitted on the forecastle deck, and three horizontal steam winches, with double cylinders, 7 in. by 10 in. stroke, are arranged one at each of the three hatches to deal with the cargo. Steam and hand-steering gear is fitted complete.

The pumping arrangements on the vessel are provided for by means of steam suctions fitted to draw from the bilges, as required by Classification Societies rules. A hand "Downton" pump is placed on the main deck, and a 4½-in. hand pump is fitted at the fore end.

We publish on the two preceding pages several views of the vessel being constructed. Fig. 1 shows a general view of the vessel with the shuttering in position, while in the adjacent berth the building of a motor ship is being commenced, and in the foreground are seen reinforcing bars, &c. Fig. 2 shows a general view from the bow of No. 99 (the Armistice), giving a clear idea of the shuttering for the frames. Fig. 5 shows the cargo ship No. 99 to the right, and cargo ship No. 100 to the left, illustrating also the vertical shuttering, while in the foreground are the bars for reinforcement. In front of the cargo ship No. 99 is the concrete mixing machine. Fig. 4 is an interior view of one of the ships with the shuttering for the double bottom and the frames. Inserted are the vertical reinforcement bars, with the hooks at the top, for staying the frames to the main deck. Fig. 3 shows the work in an earlier stage, with the vertical and horizontal shuttering being put in place while work is proceeding on the filling in of concrete on the transverse members of the double bottom. Fig. 6 gives a good idea of the transverse section of the ship and of the reinforced double bottom and vertical framing.

The vessel is built on the monolithic principle. The details of her construction are dealt with very completely in the paper read by Mr. T. G. Owens Thurston before mentioned. The steel used for the reinforcement is Trisco bars, which is a manufactured bar, having a very high tensile strength. The concrete is made up of cement, sand, and a granite aggregate. The cement used was to the best British Standard Specification, the initial setting time being not less than 50 minutes, and the final setting time not less than 5 hours. The sand used was a mixture of coarse and fine grains, of from ¼ in. gauge downwards. The aggregate consisted of granite chippings of assorted sizes, of not less than ¼ in., and not more than ½ in. Fresh water was exclusively used for mixing up the concrete. The method adopted in construction was to build a box around the reinforcement bars, in which the concrete was poured, and rammed hard round same. In order to reduce the timber used, the company adopted a system of steel sheets, suitably stiffened, to act as shutters.

The frames generally are 3 ft. apart, 16 in. deep, and 5 in. thick. A solid concrete stringer, about 24½ in. deep, extends all fore and aft at the deck level. This stringer is reinforced by bars, 1⅝ in. and 1½ in. diameter, suitably reduced at the ends. The chine stringer at the bilge runs fore and aft, of reinforced concrete, about 19½ in. deep, by 19½ in. wide, the reinforcement bars being 1½ in. amidships, reduced suitably at the ends. The thickness of the shell is about 4 in., and the decks 3 in.

The vessel ready for launching is shown in Fig. 7, while Fig. 8 shows her "taking the water." The vessel was launched in a fore-and-aft direction, on two ways placed 12 ft. apart, having a width of 22 in. The pressure on the launch-ways was about 1½ tons per square foot; the total length of standing ways was 313 ft., having a camber in that length of 22 in. The total poppet pressure was 230 tons.

Generally speaking, the severe launching conditions set out above may be taken as an adequate test of the vessel's ability to withstand any stresses which she may be called upon to meet under ordinary conditions of service. Particular care was taken with this boat with regard to all the launching arrangements, which has justified itself by the reported success of the launch. The vessel was launched over a sea wall, which in the ordinary way, would have necessitated a considerable amount of piling to support the way ends. On account of certain restrictions regarding the channel, no piling was allowed to be carried out below this wall. To get over the difficulty, a number of floating concrete pontoons were built, and sunk in position at the way ends, and upon these was built the standing ways. These pontoons can be refloated, and moved to any slipway in the yard. It will be seen that a considerable saving in cost has thus been obtained, while the adoption of the system has proved a considerable success from the launching point of view.

It may be added that soon after this company had completed their organisation and obtained a suitable site for building a number of such vessels as described above, the Government became keenly interested in the matter, with a view to placing orders for a number of vessels suitable for their own requirements, and the company were asked, along with others which were formed, to undertake the construction of ferro-concrete barges and tugs for the Admiralty. Insistence on delivery of the dumb barges, which, after all, had to trust to tugs for towing from place to place, interfered very greatly with the delivery of the self-propelled cargo steamers which were the object the company had in view at its inception, but the work on the steamers had to be put aside for the barge work. Had this not been the case, there would have been a large number of these steamers now completed; the shortage of labour, the variation of types, and the necessity of approval from various sources, necessarily and unavoidably made for delay, and also increased cost.

CHART OF PROPERTIES OF MINE GASES.—Among the recent publications of the United States Bureau of Mines is a Chart on the Properties of Mine Gases, with special regard to the sources of the gases and to their physiological effects. Thus we see in which percentages carbon monoxide and dioxide, sulphuretted hydrogen, &c., begin to produce slight and severe distress, how the cap of the flame of the safety lamp looks in the presence of methane, and how poisoned men should be revived by the Schaefer method. The tables of properties of gases comprise the ignition temperatures, critical data, explosive mixtures, and analyses of the exhaust gases from gasoline locomotives, of afterdamp, of the gases produced by the firing of various blasting agents, &c. Diagrams are also given showing the percentages of oxygen in air, at which flames (candles, acetylene, hydrogen, methane, &c.) would be extinguished when the oxygen percentage is reduced, and the diminution of the light giving out by lamp under similar conditions.

BRITISH SHIPBUILDING AND SHIP-REPAIRING.—Lord Pirrie, the Controller-General of Merchant Shipbuilding, issued, on the 7th inst., a circular letter, in which he states that the shipyards are free to take on private work, and shipowners are now in a position to negotiate direct with shipbuilders with regard to new construction. He adds that the Shipping Controller has agreed to authorise shipowners to place their repairs with the shipbuilding and ship-repairing firms in such ports as they have hitherto been accustomed to use, or wherever it may be most convenient for the repairs to be effected. Also with regard to repairs abroad, he states that shipowners may now place this work through their own agents, but he urges upon shipowners the prior claims of the "home yards." As large numbers of men are now returning to the shipbuilding industry, British yards will soon be in a position to resume their old work, and it is most essential for our yards to have work ready for the men on their return. The results which have been achieved during the past year would have been impossible had it not been for the great help, co-operation and loyalty which have been extended by the employers and men in the ship-repairing establishments as well as shipbuilding and marine engineering industries, and he again wishes to express his grateful thanks to all concerned.

PIG-IRON AND STEEL (FRANCE).—The British Chamber of Commerce, Paris, states that the French Minister of Industrial Reconstitution has decided, in agreement with the producers and the principal syndicates of consumers, that the restrictions and formalities for orders for steel from French works will cease as from December 18. The production is, in fact, now considered sufficient to meet demands. Priority of delivery will continue to be granted for steel required for reconstruction purposes in the liberated regions. Thanks to measures taken recently to lower the price of coal, maximum prices have now been fixed for steel. The basis price for commercial steel will be 60 francs per 100 kg. on rail at works, which constitutes a drop in price of 35 francs compared to previous prices. The cost of pig-iron will be reduced in the same proportion. For hematite pig-iron, for instance, the price, which was 455 francs, will now be about 320 francs. This reduction and the suppressing of all formalities for orders placed by consumers with existing works in France, will facilitate the speedy resumption of economic life. Detailed schedules of prices will shortly be published, and these prices will hold good for orders placed as from November 11, 1918, and will remain in force until March 31, 1919. No further reduction in price may be expected before that date. The Chamber of Commerce calls special attention to the fact that all formalities for steel placed by consumers with producers in France are suppressed, and the visas previously required are now superfluous. As regards pig-iron, however, the Comptoir des Répartition de Fontes will be temporarily maintained.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—As is usual in normal times a rather poor start was made when the works resumed on Monday, after the New Year holiday. The long strain of constant and arduous work has been very severe, and now that the urgent necessities of the war no longer exist the men have been in no hurry to return to the tasks awaiting them. Steel is in such heavy demand that every mill will be actively employed for many months to come, while if orders continue to flow in as they have since the signing of the armistice there is every likelihood that further extensions will be rendered necessary. Although Government is now out of the market to a great extent, general constructional work will take its place, and the arrears which have to be made up will keep all the available plant occupied. In the shipbuilding yards also, large quantities of plates, shapes and sections will be required for the heavier class of vessel which will now be built instead of the light Government craft. It is fully expected that export will develop very shortly, as soon as the more pressing needs of home consumers are got well in hand and better transport conditions are possible. A considerable amount of repairs to plant and machinery has been put through during the holidays.

Malleable Iron Trade.—So far there is no appearance of Government relaxing its control over malleable iron, a circumstance which will do much to steady the market until business returns once more to normal conditions. Manufacturers have reason to be pleased with the exceptionally brisk demand for malleable iron, and every effort will be made to satisfy this demand in the best manner possible. Meantime, of course, the home market must receive first consideration, but as pivotal men are demobilised and iron workers and miners return to their former employment the present tension will be greatly relieved, and an extensive development of export trade put in motion. Considering what export means to the country generally, manufacturers are naturally anxious not only to have it reinstated on its former level but to push ahead and give it a greatly increased importance. An advance of 15s. per ton has taken place in the price of "Crown" bars for home consumption, and 18l. 10s. is now quoted net at works.

Scotch Pig-Iron.—In the pig-iron industry smelters have much lee-way to make up before supply and demand run on an even level. The cessation of work in the iron and steel-making establishments has enabled smelters to make some little headway, but the end of the holiday period will probably leave them still much in the same position as formerly. The scarcity of foundry iron, which has been a feature of the industry during the years of war, still continues, although there is every expectation that this drawback will soon be remedied by many of the furnaces now being used in the production of hematite being put on again to the production of foundry iron.

Clyde Shipping Improvements.—The expected boom in trade and shipping is already being anticipated by enterprising communities and organisations, and amongst these the Greenock Harbour Trustees have made a very good beginning by the reinforcement of the concrete quay and deep-water berth at Princes Pier. With a length of about 500 ft. and a depth of 26 ft. at ordinary low water spring tides, the new berth has sheds and warehouses adjoining which, it is expected, will be of the greatest possible benefit to the shipping interests of the town. On the opposite bank of the river a proposal to construct a wharf or dock at Bowling has just been mooted, and a practical offer has been made to a Committee of the Old Kilpatrick Parish Council. The projected scheme embraces not only the construction of the dock to be used for the discharge of steamers and as a coaling station for vessels sailing from the Clyde, but also the erection of a number of workmen's dwellings. Should the project ultimately take practical form, it should mean the commencement of an era of industrial prosperity with the quiet little township of Bowling, world-famed for its connection with Henry Bell and his pioneer steamship Comet.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Death of Mr. J. R. Heckley.—A familiar figure in business life in Sheffield passed away last week in Mr. J. R. Heckley, secretary of Messrs. Vickers, Limited. Mr. Heckley would have completed his half-century service with Messrs. Vickers next month. When he was appointed in his twenty-third year the clerical staff at the River Don works numbered only 15. He has served under four chairmen, and devoted practically his whole life to the service of the company, in whose phenomenal progress he took a keen personal pride.

Iron and Steel.—The long holidays make it difficult to judge the general trend of business. So far as can be ascertained, however, there is no cessation in the flood of orders which has been pouring into the city since the armistice. The difficulty with regard to fuel, it is hoped, will soon be overcome. The colliers have come back in such numbers as to rapidly send up the output of the pits and relieve the shortage which has been such a serious handicap for some months past. All round, the new year has opened with full order books, and unless demobilisation proceeds at a much more rapid rate than has been the case, serious difficulties will be experienced at an early date owing to shortage of labour. In railway steel, something like a boom is already being experienced. All the local plants are now rolling rails up to their full capacity, and heavy inquiries are coming in for axles, tyres, springs and other material. The

demand is on behalf of both home market and foreign companies. In the crucible steel trade business is taking up, and as plants are rapidly being adapted to pre-war trade and new products, a steady improvement may be anticipated. Some anxiety is felt that whilst British steel makers are opening their peace trade campaign with the serious handicap of an advance in prices of from 4*l.* to 5*l.* per ton, their American competitors, according to advices received, have already decided on a reduction on their existing maximum figures. Keen interest is being taken in the developments at the Applied Science Department of the University in the interests of the cutlery, file, edge tool and saw trades. The recently-formed Technical Society has made substantial progress. At a largely-attended meeting it was unanimously agreed to form separate technical societies for the file, edge tool, machine knife and saw industries. The formation of such societies will, it is hoped, enable all sections of the industries to meet on a common platform for discussion, and by working in conjunction with any research associations which may be established, keep in touch with all progressive movements.

South Yorkshire Coal Trade.—A steady demand continues for all descriptions of fuel. The collieries have not yet got over the holiday period. Christmas and New Year stoppages, notwithstanding, the large number of men who have been released from the Army have seriously interfered with output, and the shortage is general. Best steam hards are in strong request, especially for railway purposes, and the inland consumption having again increased, the demand is considerably greater than can be satisfied. Heavy calls are still being made for tonnage for Admiralty use, shipments from the Humber ports being chiefly confined to this department. Cobbles, nuts and slacks are all firmly held, the bulk of the output going on contract account. A somewhat serious situation has arisen at many of the inland gas works. The holidays taxed their resources, and stocks being exceptionally low difficulty was found in maintaining even a limited supply. In response to appeals the Coal Controller issued orders in several cases for emergency supplies. In household sorts, the demand continues very heavy in spite of the fact that a good deal of manufacturing coal has been diverted for domestic use. Merchants report that they have a large accumulation of orders in hand. All classes of coke are scarce and prices at the maximum. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—This week business has been resumed in earnest, and inquiries for Cleveland foundry iron on both home and foreign account are on a huge scale, so much so that only a small proportion of the business offered can be accepted. Furnaces are not working at all well, and the result is a larger proportion of output of the lower qualities than of foundry descriptions. Thus forge iron is quite plentiful. Distribution of Cleveland pig-iron amongst home customers continues to be hampered by truck shortage, though the situation is less acute than it has been. Freights for coastwise shipments are high. Shipments of Cleveland pig-iron to France are maintained, but loadings for Italy are suspended owing to congestion at Genoa. Licences for despatch to neutrals are still very difficult to obtain. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge, all stand at 95*s.*, and No. 1 is 99*s.*; whilst for export No. 3 and the lower qualities are quoted 145*s.*, and No. 1 is 150*s.*

Hematite Iron.—There is a slightly easier feeling in hematite due to recent holidays, but output finds a very ready market, and with home needs still very urgent, hardly any iron is available for shipment abroad. Though there is no immediate prospect of increased output efforts will doubtless be made in that direction at the earliest opportunity. Mixed Nos. are 122*s.* 6*d.* for home use and 172*s.* 6*d.* for export.

Foreign Ore.—There are good inquiries in the market for foreign ore. Though they are carrying large stocks consumers are prepared to buy over the current quarter.

Coke.—Coke keeps strong, and labour trouble threatens to increase the scarcity. Up to the present, however, supplies to blast furnaces are coming forward satisfactorily. Medium furnace coke is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Work has been resumed at the finished iron and steel works, and as manufacturers have heavy contracts made, and orders are coming in apace, the outlook is very bright. Output promises to be on a huge scale for some time to come. Iron bars have been advanced 1*l.* to home buyers. To home customers the following are among the principal market quotations:—Common iron bars, 16*l.* 10*s.*; steel ship, bridge and tank plates, 11*l.* 10*s.*; steel angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; chequer plates, 13*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; and steel billets, 10*l.* 7*s.* 6*d.* to 11*l.*; whilst principal export prices include: common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel joists, 16*l.* 2*s.* 6*d.*; heavy steel rails 15*l.* 10*s.*; and steel billets, 13*l.* 10*s.* to 15*l.*

Consett Steelworkers' Wages.—According to the official return received from the secretaries to the Board of Conciliation and Arbitration for the manufactured iron and steel trade of the North of England the average net selling price of steel plates at Consett for September, October and November was such, as, in accordance with the agreement entered into on March 30, 1896, to increase steel millmen's wages for the current quarter by 2½ per cent., bringing the rate to 82½ per cent. above the standard. Since the outbreak of war the Consett men have had advances equal to 70½ per cent. conceded to them.

The Shipyard Strike.—Men out on Tees-side owing to dissatisfaction with the 47-hours' week system of work number 10,000. Whilst there seems to be a pronounced feeling in favour of a 44-hours' week, the principal grievance appears to be compulsion to work from 7.30 a.m. to noon without a break for breakfast, many employees declaring that in order to be at work by 7.30 they have to leave home between 5 and 6 o'clock. Many live at a distance, and they complain that the train service to work is very inadequate.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—There is very little change to report in the general situation. At the end of last week fears were entertained that collieries might be in difficulties over their stems, but an improvement has set in in this respect; arrivals are exceeding sailings this week, and collieries are now well stemmed. Outputs are fairly regular, although the expectations of a substantially increased production have not so far been realised. Approximately 6,000 miners returned from the Army have been reinstated at the collieries, but production at many pits is still disappointing, and there is not enough coal to go round. Quotations are given to neutrals, but these are purely nominal, as there are only very small quantities released for private trading purposes. The position in regard to the supply of pitwood and transport facilities is by no means satisfactory. The supply of wagons as between pit and port is better than it was, but for inland traffic it is inadequate and there are still complaints of long delays in the return of empties. The local Allocation Committee is doing its best with the restricted quantity of pitwood available. The supply, however, is not enough to meet current demands, and arrivals of overseas supplies are far below normal.

Newport.—The Monmouthshire collieries are all fairly well stemmed, and although restricted in quantity, the supplies reaching the port for shipment are regular. Production, however, is still capable of material improvement, and in this respect the collieries have still to gain the full benefit of the services of the miners who have been demobilised and have resumed their old employment in the pits. Salesmen are experiencing no difficulty in the disposal of small as well as of large coal. It is understood that the request of the steel producers for an augmented supply of gas coal will shortly be the subject of an interview with the Coal Controller.

Anthracite Miners Strike Threat.—About 14,000 miners have tendered 14 days' notice to terminate contracts with the anthracite district unless a settlement is arrived at in regard to points of dispute which have arisen. The two chief questions at issue are the demand for Friday pays at two collieries in the district and a claim for workmen's trains at one of the local railways. The matter has already been referred to the Coal Controller, but the men are dissatisfied with the reply given by Sir Guy Calthrop. Although the disputes only affect two or three collieries, the men, throughout the district, have resolved to resort to a sympathetic strike, if necessary, in order to secure the demands of the particular men concerned. Some surprise, therefore, was expressed at the fact that the Executive Committee of the South Wales Miners, at its meeting at Cardiff on Monday, endorsed the action taken by the men. It is, however, anticipated that a settlement will be effected, and that the notices will not be acted upon.

THE ROYAL SANITARY INSTITUTE.—This institute has issued a list of the courses of lectures and demonstrations to be delivered during the coming spring term, and commencing in February. The list can be obtained from Mr. E. White Wallis, Director and Secretary, at the Offices of the Institute, 90, Buckingham Palace-road, S.W. 1.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department sends a new series (No. 72) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

STOCKS OF NON-FERROUS METALS.—In order that the trade may know the position in regard to stocks of the important metals, the following particulars are published of the stocks (exclusive of old metals and scrap) in this country in the possession of the Minister of Munitions, on January 1, 1919: Copper, 36,000 tons; spelter, G.O.B., 22,273 tons; spelter, refined, 8,017 tons; aluminium, 11,957 tons; soft pig lead, 62,852 tons; nickel, 2,096 tons; antimony regulus, 3,508 tons. It is intended to publish at monthly intervals the stocks held on the first day of each month. In addition to the above the Minister holds large quantities of scrap, mainly brass, of which it is impossible to give any particulars at present.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 10, at 7.30 p.m. Lecturette: "Warming Buildings by Hot Water," by M. H. Jones.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LANCASHIRE BRANCH.—Saturday, January 11, at 4 p.m., in the College of Technology, Manchester, Mr. G. C. Swift, of Patricroft, Manchester, will give a paper on "A Brass Foundry Problem," with notes on the melting of non-ferrous metals.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, January 11, when a paper on "Iron and Steel Electric Furnaces" will be read by Mr. J. Bibby, London, Member. The chair will be taken at 6.30 p.m.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, January 11, at 6.30 p.m., at the Institute, Dudley, Mr. Frank Somers (vice-president) will read his paper on "The Handling of Materials in Iron and Steel Works."

THE SURVEYORS' INSTITUTION.—Monday, January 13, at 5 p.m., a paper on "The Second Report of the Committee dealing with the Law and Practice relating to the Acquisition and Valuation of Land for Public Purposes," will be read by Mr. Eustace Hills.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, January 13, at 6.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough. Paper by Major H. G. Scott, Marton, on "The Practical Management of Blast-Furnace Plants in Cleveland."

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, January 14, at 6.15 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne, the following paper will be read and discussed: "The Economic Efficiency of Merchant Ships," by Mr. Alexander Urwin, A.M.N.E.C.Inst.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 14, at 5.30 p.m. Papers to be submitted for discussion: "Slips and Subsidences on the Ceylon Government Railways," by Mr. Austin George Cooper, M.Inst.C.E.; "Pietermaritzburg-Riet Spruit Deviation," by Mr. Frederick William Scott, M.E., Assoc. M.Inst.C.E. And ballot for new Members.

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—Tuesday, January 14, at 7 p.m., at the Princes-street Station Hotel, Edinburgh. Paper: "The Supply of Single-Phase Power from Three-Phase Systems," by Professor Miles Walker.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, January 15, at 5 p.m., in the Rooms of the Geological Society, Burlington House, Piccadilly. Business: Annual General Meeting at 5.15 p.m., and Address on "Meteorology: the Society and its Fellows," by Sir Napier Shaw, D.Sc., F.R.S., president.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 15, at 4.30 p.m., Ordinary Meeting: "English Carpets," by Mr. A. F. Kendrick, Department of Textiles, Victoria and Albert Museum. Thursday, January 16, at 4.30 p.m., Indian Section: "Coal and Mineral Traffic on the Indian Railways," by Mr. H. Kelway-Bamber, M.V.O. Sir Charles H. Armstrong, chairman, Great Indian Peninsula Railway Company, will preside.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 17, at 5.30 p.m., a discourse will be delivered by Professor Sir James Dewar, LL.D., D.Sc., F.R.S., M.R.I. The subject will be "Liquid Air and the War." Afternoon lectures at 3 p.m.: Tuesday, January 14, Professor Spenser Wilkinson on "Lessons of the War" (Lecture I); Thursday, January 16, Professor J. Norman Collie, LL.D., F.R.S., on "Chemical Studies of Oriental Porcelain" (Lecture I); Saturday January 18, Rev. Canon J. O. Hannay, on "The Irish Literary Renaissance" (Lecture I).

THE FARADAY SOCIETY.—A general discussion on "The Theory of Ionisation" will be held on Tuesday, January 21, from 5 to 6.30 p.m. and from 8 to 10 p.m., in the Rooms of the Chemical Society, Burlington House, London, W. 1. Sir J. J. Thomson, P.R.S., will preside over the discussion. Professor G. Senter, D.Sc., will open the discussion. Professor S. Arrhenius (Stockholm), will contribute a paper on "The Evidence for Electrolytic Dissociation." Professor S. F. Acree (Syracuse, U.S.A.), will contribute a paper on "Some Investigations bearing on the Present Position of the Theory of Ionisation." Captain J. W. McBain, Ph.D. (Bristol), will read a paper on "Some Fundamental Problems of the Dissociation Theory in Aqueous and Non-Aqueous Solutions." Mr. W. R. Bousfield, M.A., K.C., F.R.S., will read the following papers: "On Correction of the Transport Numbers for Combined Water"; "On the Determination of the Ionisation of Aqueous Solutions." Dr. N. R. Dhar (Paris) will read a paper entitled "Some Aspects of the Electrolytic Dissociation Theory." Dr. Henry J. S. Sand (Sir John Cass Technical Institute) will read a paper on "The Hydration of Ions." Professor Alfred W. Porter, D.Sc., F.R.S., will read a paper on "The Variation of Electric Conductivity of Solutions with Concentration." Dr. E. B. R. Prideaux (Nottingham) will read a paper on "Pyridine and Ammonia—Estimation and Separation." Captain J. R. Partington, R.E., D.Sc., will read a paper on "The Dilution Law." Dr. H. M. Dawson (Leeds); Professor A. Lapworth, F.R.S. (Manchester), Dr. S. R. Milner (Sheffield), Professor J. C. Philip, O.B.E., Professor James Walker, F.R.S. (Edinburgh), will contribute to the discussion. The subject will afterwards be open for general discussion.

YEAR-BOOKS AND ANNUALS.

Diaries.—The Syren and Shipping have sent us a copy of their International Mercantile Diary and Year Book for the present year. This contains a large number of conversion tables, followed by the diary proper, having three days to a page, and by information on the various countries of the world, the data including the area, population, imports and exports, banks, currency, shipping ports, &c.—From Messrs. J. Davis and Co., 30 and 31, St. Swithin's-lane, E.C., we have received a copy of their Electrical Engineers' Diary, which, besides the diary portion, four days to a page, gives 425 pages of detailed information on all subjects, printed on paper of varied tints, for the use of electrical engineers. For the convenience of those who wish to carry the publication with them, Messrs. Davis issue an edition bound in limp covers, which does not include the diary portion.—Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Manchester, have sent us a pocket diary, contained in a handsome leather pocket case.—The Pulsometer Engineering Company, Limited, are issuing a very neat waistcoat pocket diary with some pages of useful formulæ. We have also received a pocket diary from the Clay Cross Company, Clay Cross, near Chesterfield.—The Daily Mail Year Book, 1919, a copy of which has been sent us by Associated Newspapers, Limited, Carmelite House, E.C. 4, contains close upon 300 pages of information of very great general interest; the price is 1s. net.

Almanacks and Calendars.—We have received from Messrs. John I. Thornycroft and Co., Limited, Southampton and Basingstoke, a copy of their new calendar, illustrating large and small Thornycroft vessels in a North Sea engagement. Other calendars have come to hand from Messrs. H. W. Ward and Co., Limited, machine tool works, Lionel-street, Birmingham; Messrs. Edgar Allen and Co., Limited, Imperial Steel Works, Sheffield; Messrs. Clayton and Co., Karrier Works, Huddersfield; Messrs. Hulse and Co. Limited, machine tool manufacturers, Ordsal Works, Manchester; Messrs. George Fletcher and Co., Limited, specialists in colliery, mining and cement works plant, Derby; Messrs. Jones and Shipman, Limited, machine tool manufacturers, Leicester; Messrs. Peckett and Sons, Limited, locomotive builders, Bristol; and Messrs. Brown Brothers, Limited, cycle, motor and tool manufacturers, Great Eastern-street, London. We have also received a refill from the Welin Davit and Engineering Company, Limited, 5 Lloyd's-avenue, E.C.; a calendar from the Anglo-American Petroleum Company, Limited, 16, Finsbury Circus, E.C. 2, showing the Mexican Eagle Oil Company's gusher, Potrero No. 4; a monthly set of refills from Messrs. Richard Garrett and Sons, Limited, engineers, Leiston; a weekly tear-off calendar from Messrs. Ashwell and Nesbit, Limited, engineers, Leicester, London, and other cities; a daily tear-off calendar from the Superheat Furnace Company, Limited, Bradford. Other almanacks have come to hand from the General Fire Appliance Company, 11, Queen Victoria-street, E.C. 4; Messrs. W. Ottway and Co., scientific instruments manufacturers, Orion Works, Ealing, London, W.; also a nicely got-up combined blotter and diary, with memoranda slips from Messrs. Johnson and Phillips, Limited, cable makers and engineers, 12, Union-court, Old Board-street, E.C. 2; and a daily tear-off calendar from Messrs. Tilling-Stevens, Limited, Maidstone. We have further received a writing pad with calendar combined from Messrs. E. T. White and Co., engineers agents and merchants, 1, Albemarle-street, W. 1. An almanack from Messrs. R. Y. Pickering and Co., Limited, builders of railway carriages and wagons, Wishaw, near Glasgow; one from the Gardner Governor Company, Quincy, Illinois; a desk almanack from Messrs. Yeaman and Baggesen, marine and general engineers, Dundee and Tayport; and a daily tear-off calendar from Messrs. E. G. Wrigley and Co., Limited, tool manufacturers, Soho, Birmingham.

LARGE SINGLE-PIECE BOILER HEAD.—The largest boiler head ever made from a single plate is illustrated in *Power*, New York. It is 13 ft. in diameter and is $1\frac{1}{16}$ in. thick. Our contemporary adds that a specially-constructed car was necessary to take it from the Lukens Steel Company, where it was made, to the yards of the Portland Shipbuilding Company.

GAS AND ELECTRICITY.—The Coal Controller states that the moderation of the heavy demands made upon gas and electricity for industrial purposes consequent upon the armistice has enabled a larger supply to be placed at the disposal of household consumers. The Controller of Coal Mines has, therefore, agreed that, commencing with the New Year, the allowances of gas and electricity for fuel and lighting under the Household Fuel and Lighting Order, 1918, shall be increased by 25 per cent. For the present this concession relates only to England and Wales, and does not apply to Scotland. At the same time, it is proposed by arrangement with the Ministry of Munitions to suspend all restrictions on the fitting of gas and electrical equipment.

REINFORCED CONCRETE STEAMER "ARMISTICE."

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION CO., LIMITED.

(*For Description, see Page* 46.)

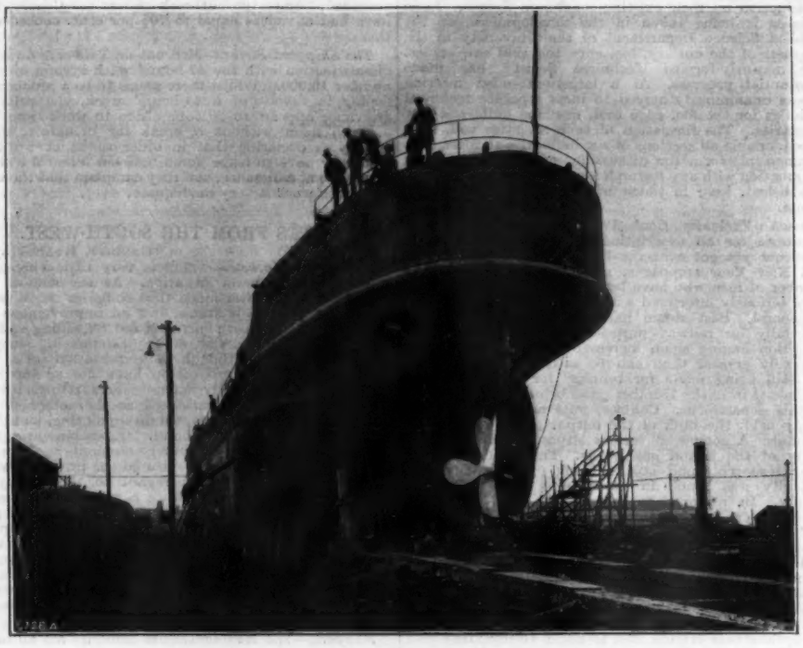


FIG. 7. STERN VIEW.

FIG. 8. THE LAUNCH.

BRITISH SHIPPING DISTRIBUTION.—The Shipping Controller is most anxious that the tonnage released from war service, which is now being re-allocated, should be so distributed as to meet all essential requirements. He would be obliged, therefore, if shippers, whether exporters or importers, experiencing any lack of sea transport facilities or any difficulty due to port congestion or other cause affecting the free movement of goods overseas, would communicate with him, giving full particulars. Communications should be addressed Ministry of Shipping, St. James's Park, London, and the cover marked "Shipping Difficulties."

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 49.

ENGINEERING.

***FRIDAY, JANUARY* 10, 1919.**

GOVERNMENT DEPARTMENTS AND INDUSTRY.

IT is inevitable that for some time industry must be under the influence of Government departments to a greater extent than in pre-war days. It is to be hoped, however, in the interests of trade development and of national prosperity, that this influence may be helpful rather than restrictive and that in any case it may be a quickly-diminishing quantity. For this reason it is in the highest degree expedient that all interested in manufacture should study carefully the report of the Committee appointed by the Ministry of Reconstruction on the important subject of the "machinery of Government," because in the course of this report considerable attention is devoted to those Government departments which exercise functions in connection with manufacturers, and particularly to the Board of Trade, the Ministry of Munitions and other great spending departments, the Ministry of Labour, and to the future supply of raw materials. The Committee was representative of many interests, and was presided over by Lord Haldane of Cloan. Its terms of reference did not involve any consideration of the absorption by the State of private enterprises, but were confined rather to the exercise of, and distribution by, the Government of its functions. We are concerned here only with those departments associated with industry, and it may be said at once that the Committee are in sympathy with the expansion of the work of the Board of Trade, or, as they prefer to call it, the Board of Industry and Commerce. They, however, seek to extend the constitution and duties of the Ministry of Labour, which they prefer to term a Ministry of Employment, having control not only in private factories but in all national concerns where labour is utilised.

The Board of Trade, prior to the war, had widely defined and somewhat limited functions. They were concerned with all industry and manufactures with a few slight exceptions, the most notable being the administration of the Factories and Workshops and the Mines Regulation Acts, which had been entrusted to the Home Office. As a consequence of our awakening under war stimulus, there have been developments at the Board of Trade in foreign trade, in the reorganisation of the consular service in foreign countries, and of commercial development in the Dominions and in the establishment of an intelligence, or general economic, department. But it is realised that much remains to be done if this Government Office is to be really effective in its services to industry. The Committee make much of the importance of a "thinking" section, a fuller control over the production and distribution of commodities, including assistance towards increase of production, and generally the watching over and the protecting of the interests of the consumer and of the community. The Department, too, it is contended, should participate with the Foreign Office and with the Colonial Office, in any step taken by the Government to develop trade within the Empire and foreign countries. An important function in the future, if the full hopes of industrialists are to fructify, is the encouragement and development of enterprise along the line of amalgamations, combinations and trusts, or even of price agreements. The department should be responsible for the correlative obligation of protecting the consumer against excessive prices, and to this end it is suggested that they should be able to bring to bear on the problems the results of experience acquired during the war in the examination of costings, the standardisation of processes and products, and the regulation of production in various stages of manufacture. They say "any control of prices in particular commodities by such devices as the sliding scale of prices and dividends under the present Gas Acts would conveniently be administered by the same authority." Although the question of nationalisation was not embraced in the ambit of the Machinery of Government Committee, they point out that just as the ministries of food, munitions, and shipping, and the buying of the Admiralty, the War Office, and other departments, seriously complicate the problem, so would the nationalisation of railways, canals, mines, &c., should this be brought about. But they take the view that the Board of Trade or the Ministry of Commerce, ought to exercise towards these State-employing departments the same supervision as over private undertakings. This is essential if private employers and the workers in private factories are to have implicit confidence in the reformed Board of Trade, because they could hardly be expected completely to trust a Government department which was itself engaged in manufactures of a more or less competitive nature. Moreover, the functions of the Ministry of Commerce are sufficiently comprehensive to demand exclusive consideration. If the highest efficiency in production is to be realised, this will "require a different range of knowledge, a different administrative method, a different aim, and therefore a different form of expert capacity from that involved in determining and maintaining those conditions of employment which it is the interest of the State, and, therefore the desire of the Government, to secure."

The difficulty arises in the complete severance of the proposed Ministry of Employment (in lieu of the Ministry of Labour) and of the reformed Board of Trade as a Ministry of Industry and Commerce. But the Machinery of Government Committee are probably right in their general provision that the immediate aims and therefore the policies of the two separate Government departments may not infrequently conflict. "The purpose of promoting private enterprise may well lead to projects and proposals which take slight account of the probable effect upon the conditions of employment, either of the persons concerned or of others indirectly affected, and these projects and proposals would need to be independently scrutinized and possibly modified in order to prevent consequences injurious to the community." The Ministry of Employment, on the other hand, must maintain proper conditions of employment, and this may involve regulations which would seriously affect the productive capacity of enterprises, so that a Ministry of Commerce and Industry, if it is to conserve the productive interests of the nation, must have the power not only of independent criticism, but of appropriate modification of such regulations.

The Committee on the Machinery of Government lay down the field of operation of a Ministry of Employment as follows: The ascertainment and regulation of the conditions of employment especially as regards wages, conciliation and arbitration, hours of labour, sanitation and safety, and special provisions relating to young persons and women; the co-operation of the State with employers associations and trade unions in their functions connected with the conditions of employment; the administration of unemployment insurance, the employment exchanges and the mercantile marine offices, so far as seamen's employment is concerned (the latter in concert with the Board of Trade); the administration of the Trade Boards

Acts, the Coal Mines (Minimum Wage) Act, and the minimum wage sections of the Corn Production Act; together with the supervision of the various Boards set up under these Acts; the administration of any provision made by the State, either directly or through local authorities, for the unemployed; such of the functions of the National Service Department as may be continued, so far as they relate to civil employment; advising the appropriate authorities as to the prevention of unemployment by the postponement or forestalling of works and contracts. The difficulty here is that there is possibility of overlapping, if not conflict, with other departments, notably, the Ministries of Health, of Education, of Home Affairs—to be in future known as the Ministry of Justice—as well as the Ministry of Finance. But it is thought that the establishment of standing joint committees, consisting of representatives of those departments which are concerned with affairs that are common to more than one department, would overcome the difficulty. One important function of the Ministry of Employment would be the collection of information about the rates of wages and scales of salary, as well as the cost of living, from time to time. This information, it is felt, would be invaluable, not only in connection with the employment of workers in industry, but to those engaged in Government factories and in all departments of the civil service.

We can conceive very great opposition to the Ministry of Employment having any control over the spending departments of the Government, notably, the dockyards. But here also the committee suggest a compromise. The functions to be transferred to the Ministry from other departments, it is suggested, should include the administration of the factories and workshops. They say the concentration in the Ministry of Employment of the functions indicated above would seem to involve the transfer to the present Ministry of Labour of the administration of the Factories and Workshops, Shop Hours and Mines Regulation Acts, and of the Coal Mines (Minimum Wage) Act now under the Home Office; of the registration and sanction of Trade Unions and their rules, now the work of the Chief Registrar of Friendly Societies; of the mercantile marine offices so far as concerns seamen's employment, now under the Board of Trade; of the Wages Boards under the Corn Production Act, now under the Board of Agriculture and Fisheries; and of all functions relating to the unemployed able-bodied which are at present exercised by the Local Government Board. The proposal, it will therefore be seen, is comprehensive, and must be very carefully studied in its details.

A further suggestion of the Machinery of Government Committee is that the Ministry of Munitions may be reconstituted as a Ministry of Supplies, in order to eliminate competition between Departments for labour, materials, and services of individual firms; to ensure that the prices paid and the conditions imposed under Government contracts for various classes of work should so far as possible be arranged upon uniform lines; to secure economies in the use of technical staffs (contracting, accounting, costing and inspecting sections). The supplies involved include not only those for all the Government departments, notably, for defence, but also a certain measure of control over supplies to private factories. This, however, is a function which ought, as speedily as possible, to revert to pre-war conditions. Nor is it intended that the new Ministry of Supplies should in any way interfere with the design, manufacture and inspection of raw material, as has been the case with munitions of war, particularly for the army and air forces during the war. For these the War Office and Air Department must in future be made responsible, as any reversion to ante-Crimean days would be disastrous. The Ministry of Supply, however, it is suggested, should be responsible for the "provision of Government printing and publications, books, newspapers, stationery and office requisites, at present undertaken by the Stationery Office as a subordinate Department of the Treasury; the provision of furniture, fuel, light, water, and household articles for Government departments; the provision of all other supplies (except any of a highly technical nature obtained by particular departments) required or purchased by the Government for civil purposes. The business of the War Office Contracts Department, as it affects the civil population, and of the Ministry of Food, so long as the activities of these departments continue, would be proper for consideration under this head." The Committee, very properly, refrain from elaborating on this important question of supplies, preferring that the scheme should be worked out by the Ministry of Munitions. But it will be seen from our brief commentary on this section of the report that their recommendations are of a far-reaching character, and consequently the report* should be very carefully considered.

THE FRENCH BRIEY-LONGWY IRON ORE BASIN.

WE have received a copy of the translation of a secret memorandum which was addressed at the close of 1917 to the German Imperial Chancellor, Count von Hertling, and to Field-Marshal von Hindenburg, by Law Councillor W. Meyer and Dr. J. Reichert, on behalf of the Association of German Iron and Steel Manufacturers, and by General Manager Voegler and Dr. Ing. O. Petersen, on behalf of the German Ironmasters. Dr. Petersen is also the editor of the German periodical *Stahl und Eisen*. The memorandum states: (1) That Germany's dependence upon foreign countries for its supply of iron ore constitutes a very grave danger to German industry and to the German State and people. It adds, (2) that forethought for the future renders the displacement of the Lorraine frontier necessary and unavoidable. In the third place, it enlarges upon the point that the mining lands (in France), which it is proposed by Germany to annex, are of enormous value for Germany's national welfare and for her waging of "a future war." A fourth and final chapter is entitled "Conclusion." The whole of the memorandum is very ably analysed in a Foreword by the translator.

The memorandum states that the iron ore supplies to Germany's enemies are fully assured, whereas the German ironfields will soon be exhausted. Great Britain, it adds, imports a large quantity of ores, and before the war Germany also obtained foreign ores from the same countries which supply Great Britain; but, the memorandum further states, there is a great difference in this respect between the situation of Great Britain and that of Germany, and it arises from the British mastery of the seas. The huge navy of Great Britain ensured for that country, even in time of war, its overseas imports, whereas Germany was at once cut off from almost all the other ore-producing countries. The foreword deals with the comparisons made in the memorandum between the German iron ore resources and those of France, and calls attention to the fact that the German authorities do not mention the Bavarian iron ore deposits, estimations concerning which were given in the German journal *Glückauf* as late as March 12, 1910 ("Die Eisenerzvorkommen in der Fränkischen Alb"), when those deposits were calculated to contain 1,700,000,000 tons, a figure which certainly represents a minimum. The translator adds in this connection that the four German specialists, the authors of the memorandum, exaggerate both the annual consumption of iron ore in Germany and the importance of the French Normandy iron ore deposits, with a view to demonstrate that France, even were she compelled to give up to Germany the Briey-Longwy basin, would still remain in possession of very great iron ore resources. It should be remarked here that the memorandum states most candidly that "few people to this day are aware that Normandy possesses such rich ore deposits, for the German prospectors kept secret from everyone the knowledge they had acquired in the very last years before the war." The Germans were not always so very pessimistic in regard to their mineral resources, for in "Gemeinfassliche Darstellung des Eisenhüttenwesens" (5th edition, 1903, the last edition we have received), a book issued by the Association of German Ironmasters, the latter, after reviewing the mineral resources of the whole world, congratulate themselves on the favourable position of Germany. The last three lines of the book state the following (translation): ". . . Under all circumstances, the prospects of Germany are more favourable than those of Great Britain, and this applies both to our (the German) coalfields and to the occurrences of ore." Since these lines were written, Germany, it is true, has lost Alsace-Lorraine, but she has ascertained the value of the Bavarian deposits above referred to.

The memorandum throws emphasis repeatedly upon the necessity of shifting the Lorraine frontier farther West owing to the German need of iron ore and to the proximity of many new and immensely important German establishments. It does this after comparing, as we have said, the mineral resources of Germany with those of "Germany's enemies," and then it states, practically in the light of an afterthought, that "by annexing all such necessary frontier areas, there would be incorporated in the German Fatherland a territory which for centuries belonged to the former German Empire." This means that if the Briey-Longwy district were absolutely barren and contained no ironstone in its subsoil, the German ironmasters would not think of annexing it, although it might have belonged formerly to the German Fatherland. Or they might have coveted it simply to increase the distance between France and the German establishments. Germany's "historic right" to the districts in question in this latter case still remains a secondary argument on the part of the German ironmasters who, it would seem, should have based their claim first and foremost upon the standpoint of history. Their brief historical data go as far back as Charlemagne; but the latter is quite as well known in French history as in Germany history. Charlemagne, in 800, was made Emperor of the West by Pope Leo III, and among the tribes he conquered were the Bavarians and Saxons. By invoking Charlemagne, France might possibly lay claim to a part of the present Germany.

The figures quoted for the production of steel in Germany in 1913, the last complete peace year before the war, are as follow, the statements we give in brackets being taken from *Stahl und Eisen*: Thomas steel (basic converter steel), 10,630,000 tons, Siemens-Martin steel, 7,977,000 tons. (This is probably made up of open-hearth steel, basic and acid 7,610,000 tons, and steel castings 362,916 tons.) Other steel is given as having reached 328,600 tons (probably made up of crucible steel 99,000 tons, electric steel 77,000 tons, and Bessemer steel 155,000 tons).

The figures for 1916 are also quoted, and are the following:—

	Tons.
Thomas steel	7,654,000
Siemens-Martin steel	8,055,000
Other steel	473,300

For both years the figures cover Germany, Alsace-Lorraine and Luxemburg.

The fact that so much basic converter steel should have been manufactured in Germany in 1916, at a time when the country was unable to meet any of its own commercial needs and unable also to export, the whole activities of the nation being exerted in meeting the war requirements, is striking and should not be lost sight of. The output of open-hearth steel is practically the same in 1916 as in 1913. The memorandum states that the quantity produced in 1916 would not have reached the figure for 1913, owing to the lack in Germany of resources in discards and scrap, and owing also to the great shortage of labour. "Fortunately," it adds, "the successes of our army enabled us to secure from the conquered territories, besides great quantities of pig-iron, semi-finished and finished products, a large amount of discards and scrap. In this, we were helped, among other things, *by pulling down the industrial establishments already devastated by war or threatened with destruction.*" The italics are ours. We may remind our readers that one of the addressees of the secret memorandum in question was Marshal von Hindenburg, who, we should think, was better than its authors, conversant with the pulling down activities of the German Army. As it is, the total steel output of Germany was 18,935,600 tons in 1913 and 16,182,000 tons in 1916; the latter figure would

* The Report, which can be got from the Government publishers, is numbered "C.D. 9230," and the price is 6d.

hardly point to the alleged "great shortage of labour."

Reverting to the figures for output quoted in the memorandum, it may be surmised that in 1916 no armour plates and very few large calibre guns, if any, were built for the German Navy; probably no guns, whether for the German Navy or Army were then built of crucible steel. We have always doubted the German assertion that their guns of recent construction were invariably built of that steel, considering the quality now obtainable in the open-hearth furnace. Krupp guns were manufactured before the war at the Cockerill Works, Seraing, and at the Skoda Works, Pilsen. The former works have been completely dismantled, no doubt because they were "threatened with destruction." An official of one of these two works asked whether he built Krupp guns of crucible steel, replied emphatically in the negative; the other firm used occasionally to purchase large naval gun tubes from outside steel makers, who may be said to manufacture tons of open-hearth steel for every ounce of crucible steel they produce. We believe that several Continental works still continue making crucible steel and also puddled iron. They, of course, find use for both metals occasionally, but their main object may be said to be the training of experienced workmen on whom they can rely in an emergency.

We wish to correct an error which has crept in the translation of the memorandum, on page 36. The authors are made to say: ". . . This was more notable from the end of 1870, when German engineers succeeded in putting to practical use the English discovery of the Thomas process . . ." The passage should read: ". . . . This was more notable towards the end of the 'seventies" and so forth. The German writers could hardly claim to have improved a process before the discovery of that process. We do not know of any such German improvement of the basic process. In regard to the early statistics of basic and other steel output, they will frequently be found to cover, besides Germany, also Luxemburg and Austria. Even then, in the early 'eighties, the figures of output given in German journals do not show sufficiently high totals to point to any German improvement of the British process in question. The German ironmasters, like the ironmasters in every other country, had to overcome the difficulties inherent to the manufacture of a converter lining, adequate in every respect, before they could make a success of the basic process. The authors cannot have had in mind the "Scheibler process"; this, so far as we can trace, was patented in Germany in about 1886, and it was claimed to require a lesser lime addition, to reduce the duration of the blow and to give a better yield in steel and in phosphoric slag. It was adopted by some German firms and was dropped by several. But, given the British basic process, or, we should say, when a firm had acquired the right against the payment of a royalty to use that process, it would seem to us that that same firm was at liberty to vary at will the addition of baked limestone to suit its own particular requirements and conditions, and this variation would not appear to be patentable, the addition of limestone forming part of the original British invention. Be that as it may, the statement that "German engineers succeeded in putting to practical use the English discovery of the Thomas process" was one which was sure to appeal to von Hertling and von Hindenburg, who probably were not so well versed in steel manufacture as in other subjects. One of our foremost authorities in the manufacture of steel, Sir Robert Hadfield, stated at the meeting of the Faraday Society on November 12 last, that "German metallurgists . . . have only copied, absorbed and made use of the principles of French, British, American and Swedish metallurgists. I cannot remember any specific instance of the Germans teaching us any basic principles in ferrous metallurgy."

The memorandum also lays great stress upon the very close connection which exists between the steel industry and agriculture, upon the value to agriculture of the phosphates obtained by the basic process. In our present brief review, this point may be viewed simply in the light of a corollary, and we need not refer to it specially.

It mentions "the future war" *ad nauseam* and states that "the displacement of our Lorraine frontiers is absolutely indispensable, not only for the security of the German Empire in a future war, but also for the consolidation of our national welfare . . ." Since Germany not only has not obtained the French Briey-Longwy basin which she has coveted for many years past, but has also lost the portion of that basin which is situated in the provinces she wrested from France in 1871, it would therefore follow that "the future war" now becomes to her an impossibility. But there remain to her the above-mentioned Bavarian deposits of 1,700,000,000 tons, upon which she appears not to have laid much stress hitherto, and the Entente Nations would still have to view contingencies with great caution. The question of "the future war" is outside our province, it is one entirely for the Peace Conference to deal with, but we may be allowed to connect the matter with a statement made many years ago in quite different circumstances by a learned British judge. He said: "The harness of certain horses contains a special strap, called the 'kicking strap.' The horse does not know the strap is there until it wants to kick; and when it wants to kick, it can't." We are quite content to leave all these questions in the hands of the Entente diplomatists who, we feel sure, will do the needful.

In conclusion we recommend the report to our readers. The English version is published in pamphlet form, under the title "German Designs on French Lorraine," at the price of 6*d*. net, by Messrs. George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, W.C. 1.

THE SENSITIVE MAN.

MODERN idea and current belief has idealised one type of man, primitive in general temperament, and has discounted another type by reason of his more civilised attitude. The first is the pugnacious bull-like individual, square in the jaw and trenchant in expression; the second is a more sensitive type whose frontage is far less aggressive. All ages have tended to produce some marked characteristics of feature and mien which seem to be peculiar to their time and place, as a study of period portraiture will serve to show. The Elizabethan and the Victorian, judging by documentary and pictorial evidence, are as far asunder as the poles are apart, so much so, that the divergence between Norman and Saxon is not more marked.

It will be contended that the age of Elizabeth was romantic and the present day realist; that imagination was the distinguishing feature of the men of the English Renaissance, and industry the hall-mark of to-day; that in type, following environment, great differences must be evident. The classification is meant to apply only to the outstanding successful man; the leader, captain, and progressive ideal human type, in short the prominent man of his age. The phrase that it takes all types to make a world is true enough; what is at the moment under discussion is whether a type successful in one age suffers a large handicap due to non-conformity while remaining the same in another. It seems on reflection that ruthlessness as a cardinal doctrine is to-day suspect if not scrapped entirely—the will to power and the power to will, both capable of grave abuse. If the present successful and admired type needs State restraint of his activities, his success may be due more to disregard for the rights of others than for any especial and peculiar capacity. Moreover, capacity mental or moral is not the point under consideration at all; the successful man may be only half-educated, savage by instinct and remarkable mainly for his lack of chivalrous honour. No man can sway the multitude, either as a demagogue, advertiser, manufacturer, producer, administrator—unless public opinion applaud; and, what is more to the point, that he enjoys the trust of a large section. His influence must inevitably be hypnotic rather than based upon pure reason, his success must depend upon the acquiescence of the community.

Now it is submitted with some show of reason that the type placed on a pedestal a few years ago has already been dethroned; he did not really exist, save as a convenient hypothesis, and his power is now broken, the illusion already spent. The popular idea has undergone great changes since the war began and legalised exploitation on a huge scale has ceased to gain admiration. It is in fact the doctrine of brute force—none the less brutal because less physical and more concealed—which has lately suffered defeat on the battlefields of Europe.

The finest human types have always despised success dependent upon prehistoric process and method, for while the scene has changed and the weapons been modernised, the underlying principles are the same.

What causes a fine brain to employ itself in the intricacies of mechanism, of medicine, of scholarship, of research, of statesmanship—certainly not the hope of wealth beyond the dreams of avarice. Even the soldier whose trade is force lives for a different ideal. It is imagination, principle, emotion, self-abnegation, which lead to the choice, for the straight issue is joined between man and nature to serve mankind, not for individual gain beyond a reasonable competence. He pits himself against natural force, not against his fellow-man, and his life is spent in amelioration of human condition and the enlargement of human resource.

Blank negation of his responsibility towards his neighbour will not serve any self-respecting individual. He cannot bring himself to believe that might is inherently right and that his mission is to trample underfoot the weak and trusting.

The applause of recent years has all been to the man who managed, irrespective of means, to become triumphant; forgetting that some are too proud to fight for a selfish cause, that undue dominance can only be won by disregard of principle and of the rights of others. The callous individual reacts only to selfish motive, he can witness suffering unmoved; with strong physique he has no sympathy with weakness, altruism is to him pure folly. In one sense his hardness may be accounted unto him for righteousness, since he is a reproach to the slothful, yet his cunning is small because he fails to realise that a man may himself be a failure and yet succeed beyond all human hope.

The gentler imaginative, sensitive man, quick to react to external stimulus; with more regard for pure justice, who endeavours to live void of offence, is by the recent false standard, if not quite a fool, still an inferior. It is here contended he is a finer type; you may browbeat him by bullying, but such methods of handling do not win his best efforts nor his respect. He is a more modern product, more civilised, more chivalrous, a better type entirely; given sympathetic environment he reaches a higher plane of achievement quite naturally and without effort. All the real pioneer work of the world, its music, literature, art, invention, design—all constructive work depends upon idealism, impossible to the type voted successful by the man in the street of a generation ago.

With the primeval man in control such men receive scant notice, their quick sensitive understanding is resented, counted unto them for weakness; it is concluded too hastily that the bully is the best executive, and the best weapon the club of brute force, not the rapier point of exquisite delicacy; yet it seems forgotten, by captains of industry in particular, that in the hands of an expert the rapier is more deadly than the club, also that it is more cleanly and less repugnant to men of taste and discernment. It is denied that romantic adventure is dead, together with the past period. All industry is an adventure which can be invested with the spirit of romance, even the patient investigations of science achieve romantic results, engineering production in particular evokes a fine ardour in the trained engineer. The view point may be too near, but romance which demands the imaginative, sensitive type of man surrounds all modern enterprise. The pity is that he is often in subordinate positions doing the real endeavour, while the control may be vested in hands of another order entirely.

Out of the present era of stress and crisis some surprising human discoveries have been made. The men who have distinguished themselves greatly have not been those whom brute force characterises—but as might be expected the reflective—those whose insight and understanding were quick

to respond to the call of change and who, in normal times, would have been overlooked, so potent is the force of a popular illusion.

NOTES.

THERMOELECTRIC EFFECTS.

IF scientists were not sufficiently burdened with definite tasks, they would do well to put their houses in order, settle the hopelessly-confused nomenclatures of branches of science and sift the accumulated masses of data of questionable value. Old facts are constantly being rediscovered and discussed from the particular standpoint of the observer, with little regard to previous investigations and to the general theory. In the field of thermo-electricity in particular old facts are frequently unearthed again and explained on novel lines; but we do not seem really to come nearer the real explanation. Two years ago, Benedicks published some experiments of his demonstrating that a non-symmetrical temperature gradient in a homogeneous wire gives rise to a thermoelectric current which he explained with the aid of magnetic fields; he considered that this was a new effect in a homogeneous circuit of the kind which Seebeck had observed in 1822 in heterogeneous circuits. Others questioned his priority and his explanation. In the Journal of the Washington Academy of Sciences, of October 4, 1918, Paul D. Foote and T. R. Harrison, of the Bureau of Standards, point out that they have long been troubled with parasitic thermo-currents in various ways: when one of two crossing wires is heated, when one wire is drawn over another, when wires of different diameters are joined, when a wire or rod is partly grooved and heated, &c. These effects really go back to Seebeck and to earlier days. Benjamin Franklin and Cavendish observed in 1769, that when a hot bar and a cold bar are made to touch one another, the cold bar becomes positively charged. That was a static charge; Ritter proved in 1798 with the aid of the galvanometer of his days, a pair of frog's legs, that a current flows from cold zinc to hot zinc. Seebeck joined two dissimilar metals, antimony and bismuth, heated the junction and obtained thermoelectric currents; he then arranged the metals in a thermoelectric series which changed when the temperature was altered. He also found that a current was set up in an asymmetrically-heated single wire and he ascribed this current to the hardening and softening of different parts of the wire. Peltier made the converse experiment of Seebeck in 1834; sending a current round two junctions he observed that the hot junction was cooled, when the current direction was Sb-Bi, and the cold junction heated, or *vice versa*; he also found these effects to be reversible. William Thomson, in 1856, noticed currents in combinations of copper wires, some stretched, the others unstretched, and he showed in general that an electric current absorbs heat when it passes from hot to cold portions in copper and evolves heat under the same conditions in iron (Thomson effect). Trouton, in 1886, studied the currents generated in a homogeneous wire along which a gas flame was moved; similar effects were described by Bachmetieff, Egg-Sieberg and others. The Benedicks effect looks like a special case of the Nernst-Ettinghausen effect, which is the thermo-magnetic analogue of the Hall effect: when one of the ends of a strip of metal foil is heated, and the other end cooled, there is no current between symmetrically-situated points, and there should not be any current; but when the strip is placed in a magnetic field, such currents are observed, and the direction of these currents in iron is opposite to the direction of these currents in most other metals. Thermo-currents in iron generally differ in direction from those in other metals; but there is great diversity, and this peculiarity is one of the points which the many various theories of thermoelectric currents do not explain. Considering the importance of the electron in all modern electric theories, it is rather striking that nobody seems to have attempted yet to give an electronic theory of thermoelectric currents.

MALLEABLE CAST IRON.

The composition of malleable cast iron is restricted to narrower limits than that of grey iron. It is not considered advisable to use a malleable cast iron containing more than 0·2 per cent. of sulphur and 0·4 per cent. of manganese; as to phosphorus opinions differ. Silicon should be present to keep down the porosity; too much silicon, above 1·2 per cent., favours carbon segregation however. All the mechanical properties being much affected by the length of the decarburisation period, the influence of this period and of the silicon percentage were particularly studied in 1917 by A. Leuenberger, of Schaffhausen, at the Aachen Technical High School (*Stahl und Eisen*, vol. xxxvii, pages 513 to 521 and 601 to 610). Preliminary tests having convinced Leuenberger that, owing to the irregular distribution of carbon in cast iron, little reliance can be placed on a few experiments, he proceeded to a systematic investigation, which is all the more interesting since little systematic work has been done on this kind of iron. In the preliminary experiments he turned test rods, varying from 23 mm. down to 11 mm. in diameter, from a malleable cast iron containing 0·57 per cent. of silicon, all the rods being treated in decarburising furnaces for 150 hours. The tensile strengths of the rods seemed to remain constant as the diameters were reduced from 23 mm. down to 20, 17, 14 mm.; but on further reducing the diameter to 11 mm, the strength suddenly dropped from 32·5 kg. per square millimetre to 24·6 kg. For the further researches therefore, 17 charges, each of 600 kg. were cast in iron moulds and slowly cooled in them. Ferro-silicon was added to vary the silicon percentage from 0·17 to 1·08, and 40 specimens were prepared for each of the series of tests. The decarburisation was effected by heating the specimens, together with hammer scale (partly fresh and partly used already, to mitigate the oxidation) up to 980 deg. C, for five periods of 95, 130, 175, 225, 260 hours; these numbers indicate the total periods, the heating-up took twelve hours, the cooling 32 hours each time. The first heating reduced the carbon contents by 84 per cent., the fifth by 96. This decarburisation was less marked as the Si increased to 0·65 per cent., and became more pronounced again as the Si further increased, the relative figures for the reduction in the carbon content by the first heat being 84, 67, 74·5 per cent. for the minimum, medium, and maximum Si percentages. The other elements had no distinct influence in this respect. The tensile strength decreased with prolonged heating, the elongation and contraction of area increased decidedly; the silicon percentage had no influence on the tensile strength, and counteracted the increase of the latter two quantities. The notched-bar impact tests gave higher values as the heating was prolonged, rising from 2 kg. per square centimetre after the first heating to 8·4 kg. after the fifth heating; in the three first heatings the increasing silicon percentage made no difference, but after the fifth heating the maximum silicon percentage reduced the work done in fracture to less than half its value for the minimum silicon content. The Brinell-hardness decreased with heating, the density likewise, the latter especially with high silicon percentage. As regards changes in length, metal containing 0·55 per cent. of Si was not affected by heating; the malleable iron less rich in Si contracted, the metal richer in Si expanded. The electric resistance determined with a Kelvin double bridge increased with raising Si content in the untreated metal, this being a cementite resistance; in the treated material the (ferrite) resistance decreased to less than half its value, the curves being fairly parallel to one another. Rusting tests continued for 20 days did not reveal any distinct influence of the silicon per centage or heat treatment. On the whole prolonged decarburisation and low silicon percentage appear recommendable because they make malleable iron tougher, though the tensile strength may diminish.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—A conference on "Reconstruction or Restoration" will be held under the auspices of the Industrial Reconstruction Council on Tuesday, the 14th inst., at 6 p.m., in the Hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4. The chair will be taken by Sir Henry Urwick, of Messrs. Fownes Brothers and Co., and the opening address given by Major H. J. Gillespie, D.S.O., after which will follow questions and discussion. No tickets are necessary.

INDUSTRIAL NOTES.

WRITING in *The Federationist* for the present month, on the Labour Party's tasks, Mr. W. A. Appleton states that the maintenance of the export trade should claim instant attention, because upon this maintenance depends the well-being of those who are engaged in industry. A considered inquiry into the capacities of the world's food-producing centres and an ordered effort to secure ample supplies of food at reasonable prices, should be put forth immediately. The party might wisely turn its attention to the study of industrial economics, not for the purpose of controversy, but for the purpose of scientific construction. The war has compelled the nation to pawn its resources. Only the patience and effort which come with understanding will enable these resources to be redeemed without disaster. Sooner or later, circumstances will force upon the people the truth concerning the real value of paper money which is not covered by intrinsic reserves, and when this day comes a Labour Party that has familiarised itself with the facts of international trade and finance will be of inestimable value to the Empire.

In the more purely domestic areas the party may do much to persuade the youth of the nation to take advantage of the educational opportunities which are now so freely afforded.

There is no royal road to success for either parties or men. Work for the love of work, and not as a means of advertisement, is the condition precedent to success. The beatitudes give the earth to the meek.

The same journal contains an article on "A Shorter Working Week," signed by A.S.E., which we reproduce below:—

During December the Amalgamated Society of Engineers and the unions affiliated to the Engineering and Shipbuilding Trades Federation have been taking a ballot vote *re* a joint recommendation for a reduction of the working week to 47 hours, as from January 1, 1919.

It is to be regretted that when the members of these unions were asked to vote they were not in possession of the whole of the conditions attached to this concession.

It was stated that the concession carried with it the introduction of the "one-break system," and that "wages and other working conditions should be maintained," but Clauses 3, 4 and 5 of the recommendation were too indefinite for any member in the branch to estimate what was covered by them.

In Clause 3 the unions are to agree to take all possible steps to secure the greatest possible output and to maintain it.

This will be quite a new duty for trade union officials, as it has been their previous practice to protest against the "feed and speed man" in the workshop, and when one comes to remember past years and past speeches of leaders, one wonders what the members will think of their officials filling this office.

Clause 4 reads: "The economic conditions and systems and basis of remuneration necessary in the interest of industry shall be the subject of early consideration, and the parties agree to deal with these conditions from a broad national standpoint."

This is clearly getting in the "payment by result," and those who have spent their lives in support of day-work wages, and those who have protested loudly against piece work, &c., will have to reconstruct their positions.

Clause 5 provides for bringing all these trade unions under the provisions for avoiding disputes, at present in operation between the Engineering Employers' Federation and certain trade unions.

Many societies have up to the present refused to be subject to these provisions, but the acceptance of this recommendation will carry with it their submission, and their surrender of the right "to go as you please."

It is to be regretted that the recommendation was not completed before submission to the ballot, as it is to be feared that friction will arise when the scheme covered by Clauses 3 and 4 comes up for review by the members in the branches, as only then will they realise that the recommendation not only gives but takes away.

It is also to be regretted that in taking this vote the whole of the resolution passed by the conference of workers' representatives was not published, and we here give the part omitted:—

'The conference, in view of the important nature of the proposals, agrees that they should be at once referred to the executive of each union with a request that they be submitted by ballot to their respective membership on the definite understanding that any proposals for securing the application of Clauses 3, 4 and 5 shall be submitted to each trade union before being put into operation."

This omission may cause trouble later on, seeing that no provision is made for a further ballot on Clauses 3, 4 and 5 of the members who will be subject to them,

hence our contention that it is unwise to submit an incomplete recommendation for ballot, as such a course is apt to lead to difficulties later on.

Lord Armaghdale presided over the annual meeting of the shareholders of Messrs. Levinstein, Limited, held on Monday, December 23, and stated that the amalgamation between British Dyes, Limited, and his company was now practically an accomplished fact.

He added that prior to the war the Germans had acquired a control over the textile trades of all countries of the world. It was one of their most potent forms of peaceful penetration, the political importance of which in India, China, Russia, Persia and the Near East had never received proper recognition. In our own country, the danger of being dependent upon Germany for a supply of dyestuffs was now clear to everybody, but prior to the war this was not the case. When war broke out, a process was going on in Germany to absorb all dangerous rivals in the dye industry; the moment that this scheme was completed, and it had been very near completion, consumers in this country would have realised their danger and would have been ready to fight against it, but it would have been too late to take effective measures. The Germans were, as all knew, specious and plausible while acquiring domination, but entirely arbitrary and unscrupulous.

There was, he further stated, a far greater amount of chemical talent in this country than was generally realised. A great deal of it was never previously enlisted in the public service, but during the war purely academic chemists had rendered considerable service to the State in investigating new substances and devising new processes for offensive and defensive warfare. This had brought many university professors for the first time in touch with manufacturing requirements. Their experience, he trusted, would prove of advantage both to pure science and also to industry, particularly to the dyes industry, which was based on science and lived by scientific research.

The old academic tradition that research work which would lead to immediate practical results was beneath the dignity of science, was dying out. Nobody desired universities to neglect research on subjects of abstract and purely theoretical interest, but nobody rejoiced more than the leaders of the dyes industry at the closer feeling of unity which had been established between the leaders of pure science and the leaders in the application of science to industry. Brilliant men who formerly stood apart were now anxious to help, and the practical men who knew how to use their assistance welcomed them most cordially, and required their aid. He (the speaker) for one, would never believe that we in this country, roused at last to battle in the domain of science, would prove unequal to our task.

Lord Armaghdale concluded by stating that in the last strenuous years' work the company had received the most loyal and whole-hearted co-operation from the staff. Work had been very heavy and the hours long, but all had risen to the occasion in the knowledge that by their efforts they were doing their duty in the great struggle. The company's relations with their workpeople had also been of the happiest, and it was his earnest hope that the new corporation would be served with the same faithfulness and goodwill as the old firm. He offered his own personal thanks and those of his colleagues on the Board to the staff and the workpeople.

We are informed that the Derbyshire Miners' Association are making a determined effort to have shovels substituted for forks and riddles in filling coal in the collieries throughout the country. A meeting was held last Saturday at Chesterfield, when it was decided to hold lodge meetings on the subject at all pits during the ensuing fortnight. It was hoped that the change will be brought into general operation on Wednesday, the 22nd inst.; the replies of the lodges are to be sent to the head offices by the 18th inst.

This has been for some time past a vexed question, viewed from two different standpoints by the miners and the colliery owners, the ultimate loser being the Nation. We hope an agreement will be arrived at between the owners and the men, and that the result of the agreement will be that no fraction of the coal mined will be allowed to remain underground and thus become irretrievably lost. That coal should be wasted in this way is much to be deplored. Professor Louis, of Newcastle, called attention to the subject several years ago.

With reference to the 47-hour week in the shipbuilding and engineering trades, Messrs. Vickers have arranged with representatives of the Barrow workmen, to commence this week with the following hours: Monday, Tuesday, Wednesday, Thursday and Friday, 7.30 to 12, and 1 to 5; Saturday, 7.30 to 12.

With the general release from Government control of raw materials used in industry, the necessity for rationing disappears and the Civil Industries Committee, through whom that rationing has been exercised, is now to be disbanded.

The committee was appointed by Dr. Addison, then Minister of Munitions, in February, 1917, under the name of the Priority Advisory Committee. Its duties were to investigate the claims of industries threatened with hardship or extinction, owing to the shortage of raw materials, and to make arrangements whereby they might at least be kept alive, even if not maintained at their former level. The committee was composed mainly of business men of such standing as to give to the traders of the country a feeling of confidence that their interests would be safeguarded. The chairman was Mr. John Wormald, of Mather and Platt, Limited, engineers, Manchester, and his fellow members were: Mr. G. E. Alexander (chairman, United Glass Bottle Manufacturers' Association); Mr. Kenneth M. Chance (British Cyanides, Limited, Birmingham); Sir Archibald Denny, Bart. (William Denny and Brothers, Limited, shipbuilders, Dumbarton); Mr. Alexander Walker (John Walker and Sons, Limited, Kilmarnock); Mr. Murray Walker (Walker Brothers, Limited, East India and South African Merchants); Mr. Henry Woodall (director, Gas Light and Coke Company).

Although the work of the committee was largely in trades dependent upon supplies of metals, it dealt also with the rationing of chemicals, oils, fats, the last-named in co-operation with the Ministry of Food. In addition, the committee from time to time, by arrangement with the Minister of Reconstruction, investigated claims made to him for materials, plant and machinery required in preparation for the resumption of peace-time work or for the starting of new industries.

From the outset, the committee worked on the principle of winning the co-operation of the traders themselves. No decisions were made without consultation with representatives of the industries concerned, and the meetings between the two sides were full and frank. It has met for almost two years twice a week regularly, and in its earlier months three times a week. The chairman, Mr. John Wormald, has given the whole of his time to the work, assisted by Mr. Frederick Simmons, and by Miss Fraser as secretary, with no other staff. For their valuable services, the committee have been warmly thanked not only by the Government but also by the traders whom they rationed.

IRON AND STEEL STOCKS.

In a recent announcement relating to the prices of iron and steel it was stated: (1) That the powers of the Ministry of Munitions would be used to prevent any undue hoarding of subsidised material in anticipation of a subsequent rise in price; and (2) that during the period of subsidy, distribution of cheap material should be made on an equitable basis.

After discussion with the industries concerned, the Ministry of Munitions has now made the following arrangements in these two respects:—

1. As regards stocks of iron and steel held by makers, stock-holders or other persons dealing in or being consumers of iron or steel, it is considered reasonable that stocks should be restored to a normal level out of subsidised material. It is, therefore, proposed that such persons should be permitted, without any claim by the Ministry for repayment of subsidies, to replenish their stocks up to a total not exceeding 100 tons above the amount held by them on October 31, 1915 (being a date prior to the period of control), or October 31, 1918 (being a date approximating to the conclusion of hostilities), which ever amount may be the greater. On any excess, however, beyond these quantities free of rebate, each person will be required to pay to the Ministry of Munitions a sum per ton, to be announced at an early date, in respect of the subsidies on any such excess held by him as at April 30, 1919.

In order to carry out this scheme, an Order will shortly be issued requiring all persons holding, on April 30, 1919, 100 tons or more of iron and steel or either of them, to make a return to the Ministry of Munitions of their stocks: (a) At October 31, 1915, or October 31, 1918 (which ever may be the greater); (b) at April 30, 1919. This return will be subject to verification by the firm's auditors or by the accountants of the Ministry of Munitions, and will be in accordance with a form shortly to be issued. This form will be as simple as possible, and will exclude special classes of iron and steel which are not subject to subsidy.

All iron and steel not actually incorporated in any building structure or work in progress will be regarded as stock to which the above applies.

The Order will further contain provisions for securing payment to the Ministry of Munitions of the sums above-mentioned in respect of any excess stock held on April 30, 1919.

2. In order to secure equity of distribution of iron and steel the Minister of Munitions invites any trade association or individual consumers who may have reason to complain of difficulty in obtaining supplies of iron and steel, to seek the assistance of the Secretary of the Area Committee of their locality. Such complaints will be dealt with by the Area Committee, and, if necessary, representatives of the industry or firms concerned will be invited to attend a special meeting of the committee. Appeal may, if desired, be made to the Central Steel Committee of the Ministry of Munitions.

The names and addresses of the secretaries are as follow:—

Area.	Name.	Address.
Scotland ...	G. W. Langford	105, West George-street, Glasgow.
N.E. Coast ...	W. E. Bowles	North-Eastern Bank Chambers, Middlesbrough.
South Wales ...	Henry Clement	25 to 29, Royal Metal Exchange, Swansea.
Midlands ...	D. J. Suter...	Phœnix Buildings, Colmore-row, Birmingham.
Sheffield ...	N. Thomas...	Angel Hotel, Angel-street, Sheffield.
Manchester (including N. Wales and N.W. Coast)	G. Throssel...	Victoria Buildings, 81, Mary's Gate, Manchester.

Consumers in London or localities outside the above iron and steel areas should communicate direct with the Secretary, Central Steel Committee, Ministry of Munitions.

SHIPPING OF FUEL OIL.

The Ministry of Shipping forwards the following for publication:—

Various statements have been made relative to the "double-bottom" scheme of carrying fuel oil across the Atlantic, and in view of the remarkable results achieved by this scheme, a short account of its development and working may be of interest.

The use of the double bottoms, or ballast tanks, of ordinary cargo steamers for the conveyance of fuel oil has been known to the Admiralty for many years, and certain steamers had been adapted for the possible supply of the fleet by this method. It had been the practice to convey oil by this means from the Far East. In 1915, the Anglo-Saxon Petroleum Company suggested to the Admiralty the possibility of developing this method to supplement tank steamers in conveying fuel oil to this country, the technical details of the scheme being worked out by Mr. C. Zulver, the marine superintendent of the company. The policy was adopted—but only to a limited extent, owing to the impossibility of displacing "heavy" cargoes such as wheat, manganese ore, &c., which were vitally required in this country. Credit is due, however, to Messrs. A. Holt and Co. for their pioneer work in fitting their steamers under the scheme in its limited form.

In June, 1917, owing to the intensive submarine warfare, and the enormous growth in the consumption of the Navy, it became apparent that unless the quantity of tank tonnage were increased to a very large extent indeed, and in a very short time, the stocks of petroleum products in this country would sink to an alarming extent. It was accordingly decided to give the conveyance of fuel oil absolute priority over all other classes of cargo, and the Ministry of Shipping at once worked out a scheme, in conjunction with all the principal liner companies, for fitting their steamers for the conveyance of fuel oil in double bottoms and deep tanks; and no time was lost in extending the scheme to tramps. Appreciation is due for the good work done in fitting the steamers to the technical staffs of the liner and other companies concerned, and to the Anglo-Saxon Petroleum Company, whose engineers were employed by the Ministry of Shipping both in the United Kingdom and in the United States of America, to supervise the work. The services of Mr. Zulver were particularly valuable in this connection.

It became necessary in May, 1918, to limit the operation of the scheme somewhat in order to carry the largest possible number of United States troops, and on November 5—the reserves of petroleum products having reached a certain level, and it being possible to maintain that level by tank steamer—it was decided to discontinue the scheme.

Apart from the valuable results achieved by this scheme during the war, the experience gained of carrying oil in this manner will certainly be of value in connection with the development of petroleum as a fuel for steamers after the war. The following figures in connection with the scheme may be of interest:—

Date of approval of extended scheme	June 21, 1917.
Date shipments commenced...	July 3, 1917.
	Tons.
Quantity carried to June 1, 1918 ...	746,930
Total quantity to November 11, 1918	1,014,570
Quantity per day	2,045
Number of ships fitted:	
In United Kingdom	430
In United States of America ...	331
	761
	Tons.
Quantity of oil lost in transit by enemy action	15,191
Quantity of oil lost in transit by marine loss	2,201
Total	17,392

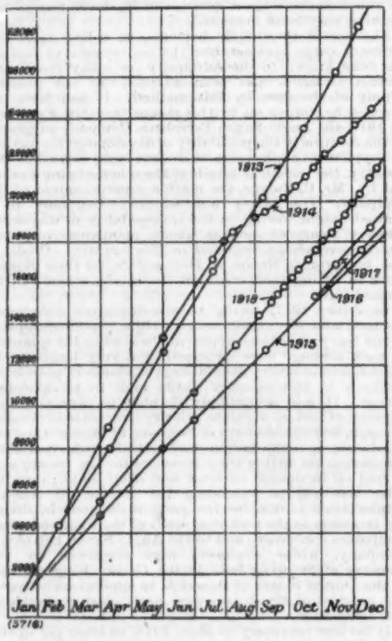
Personal.—The directors of Messrs. William Muirhead and Co., Limited, of 40, Parliament-street, Westminster, call attention to the altered designation of their firm, which will in future be William Muirhead, Macdonald Wilson and Co., Limited. The constitution of the company remains unaltered.

PATENTS AND THE WAR.

It is well known to those accustomed to investigate such matters that the fluctuation of applications for Letters Patent is a measure of the change of industry in the country, and if the industry be considerably upset, it will immediately be indicated on a curve showing the relationship of patent applications with respect to time. Such a curve showing how the beginning of the war affected patent applications is to be found in ENGINEERING, vol. xcix, page 53 (January 8, 1915).

It is now possible to review the effect of the war as a whole on these applications, and the following curves show the result. As a standard in the first place the curve for 1913 has been drawn, and it will be seen to be substantially a straight line. That for 1914 begins almost identically, but it will be noticed that a sharp turn takes place almost immediately after the beginning of the war. The Austro-Hungarian note to Serbia, it will be remembered, was delivered on July 3, and Britain declared war on Germany on August 4, 1914.

In 1915 and 1916 the curves are again of the order of straight lines, in fact, they are almost exactly so. Not all the points examined have been plotted, or the result would lead to confusion, but sufficient indication is given in the diagram. It will be seen, by comparing the slopes of the two lines, that there was an increase in



the applications in 1915 compared with the war period of 1914, and a further increase in 1916. Similar remarks apply to 1917, that is to say, there is again an increase, but there is no point of flexure on the curve.

Coming to 1918, it will be found that the straight-line law almost exactly holds to the end of October. The remainder of the curve is again a straight line, but the slope is steeper than that of the earlier part of the curve. The effect is striking on a large scale, but is quite clear even on a small scale.

Examining a diary of the war, the following gives the most important events at about that period of change in the curve :—

September 25, 1918, Bulgaria sues for peace; October 1, armistice signed; October 7, Prince Max announces that he has approached President Wilson to arrange for an armistice and peace; October 17, Lille and Ostend taken; October 20, Zeebrugge occupied and Belgian Coast cleared; October 20, Bruges taken; October 23, President Wilson's note to Germany, armistice terms referred to the Allies. Evidently, therefore, the point of intersection of the two lines indicates the beginning of the end of the war.

With regard to the total number of applications in the several years, they are as follow :—

1913	30,102
1914	24,847
1915	18,225
1916	18,686
1917	19,358
1918	21,933

Taking 1913 as a standard, the approximate change in any year with respect to the preceding year is as follows :—

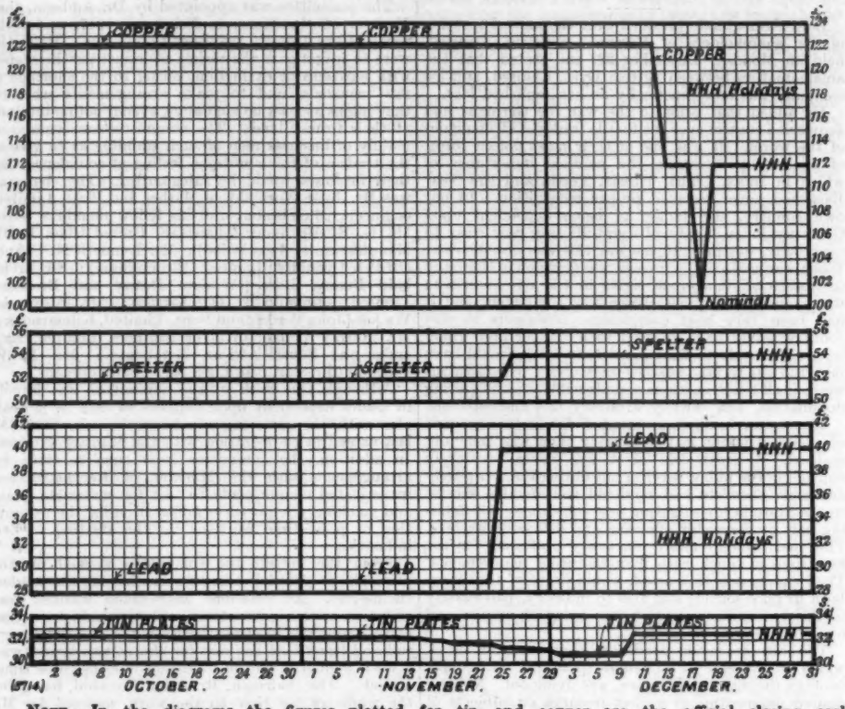
	Per Cent.
1914	— 17
1915	— 27
1916	+ 2
1917	+ 4
1918	+ 4

As a matter of interest, it may be remarked that by no means all the applications lodged mature into patents. The general proportion is of the order of 50 per cent. The figure for any given year of the war period will bear no true relation to what is actually happening, because under the temporary rules that have been made from time to time, various changes in procedure have occurred. According to one of these applications in the names of enemy subjects were allowed to proceed as far as the acceptance stage so that they then became open to the public, but no patents were sealed on them. Again, under the Regulations for the Defence of the Realm a large number of cases belonging to certain war classes were not allowed to pass as far as the acceptance stage. It has recently been decided that these shall be passed for acceptance in March next, it being anticipated that about 80 per week will be dealt with. Thus the proportion of applications in any given year and the patents sealed during that year will be materially altered. Owing to this prohibition of the publication of war inventions, it is not possible at the present moment to examine the trend of invention during the later stages of the war, but figures should be available in the near future.

Numbers of applications have been made for the avoidance of enemy-owned British patents, but here, again, all the figures have not been issued. The general way in which matters have been dealt with can be followed from the fact that in 1915, 154 applications were made and 117 were granted; in 1916, of 96 applications made 56 were granted; and in 1917, of 223 applications made 178 were allowed.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. (For official regulations see page 45, vol. cii.) A new series of prices for iron and steel has been issued, and appeared on page 646 of our issue of December 6, and on page 23 of our issue of January 3. The Minister of Munitions has also issued certain regulations controlling the prices and dealings in non-ferrous metals; these restrictions were removed on December 17.

BRITISH RAILWAY REFORM.

A CONFERENCE was held on Thursday, the 2nd inst., at Princes Restaurant, Piccadilly, under the auspices of the Federation of British Industries, with Mr. Marshall Stevens, M.P., in the chair, to discuss the question of Railway Reform. Besides the vast interests of the Federation of British Industries, which in itself represents 4,000,000,000*l.* capital, eight trading associations were represented, and many prominent experts attended.

The following memorandum was read in regard to the present position of the State, the railways, and traders :—

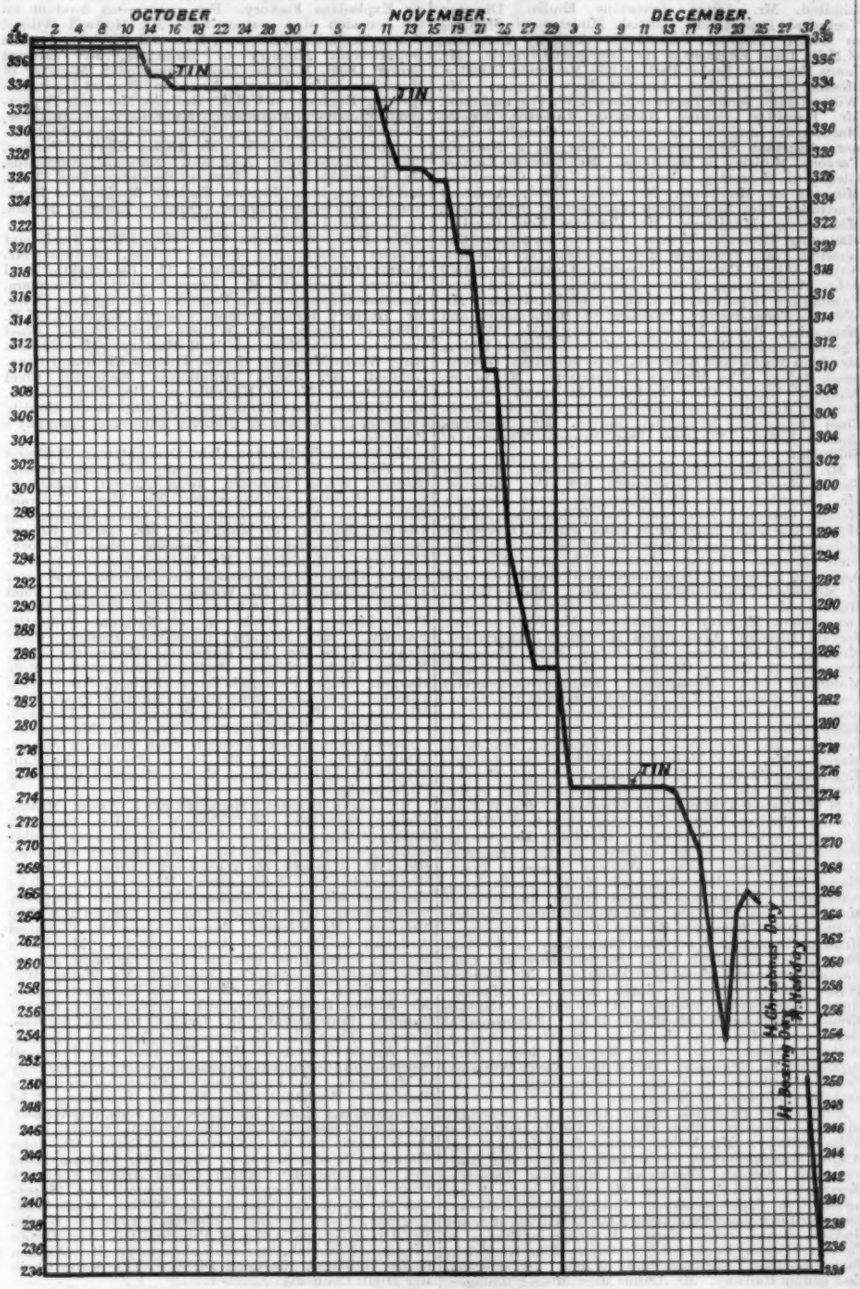
Some time before the war a Royal Commission was appointed to consider the question of the relation between the State and the railways. The sittings of this Commission have been discontinued during the war. Immediately on the outbreak of hostilities the Government, in virtue of the powers they had, took over the control of the railways of the country, with the exception of one or two important and a few small railways, and appointed a number of railway managers, together with the President of the Board of Trade, as an Executive Committee for the management of such railways as were controlled. The connection of the President of the Board of Trade with the Railway Executive Committee is almost entirely formal.

The State has guaranteed the railway companies, under certain conditions, a net revenue equal to the revenue which it earned in 1913. No accounts of a detailed nature have been published by the controlled railway companies during the war. The State has in effect had the free user of the railways for the transport of passengers and goods. The railway executive has, during the course of the war, framed regulations under D.O.R.A., many of which have brought into operation (ostensibly for the period of the war) practices to which traders had successfully objected in the past.

Until, in the recent election campaign, Mr. Winston Churchill declared, in answer to a casual question, that the State had decided to nationalise the railways, it was thought that no final decision had been come to by the Government in this respect, pending the report of the Royal Commission previously referred to. It is not yet clear whether Mr. Churchill was speaking for the Government, or exactly what is meant by nationalisation. Whether it means the economic or financial ownership of the railways by the State, or whether it

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



means that the State will operate the railways. There is a broad distinction between these two methods of control. Apart from the political side of the question, the traders of the country in the main, are averse to the nationalisation of the railways, and are more strongly opposed to State operation than they are to State control through economic or financial ownership. Whatever may be the future position as regards the railways, it clearly behoves the traders to see that their position is improved, by any legislation which the Government may introduce dealing with railways.

A Select Committee of the House of Commons was appointed on August 5, 1918, for "the purpose of considering what steps, if any, it is desirable to take to develop and improve the internal facilities for transport within the United Kingdom, to secure effective supervision and co-ordination and to insure that such developments and improvements shall be adequate and suitable to meet the national requirements."

In their second report ordered by the House of Commons to be printed on November 4, 1918, the committee, after setting out various considerations, came to the conclusion that the main railway systems of the United Kingdom should be brought under an unified ownership, and managed as one system if the question of the improvement and development of the internal transport facilities is to be considered from the standpoint of efficiency and economy, and with due regard to the interests of the proprietors, the railway staff and the general community.

The committee regretted that, owing to the close of the session, it had been unable to complete the work entrusted to it, and is of opinion that Parliamentary inquiry by the Select Committee into the question of inland transport should be resumed at the earliest possible date in the next session of Parliament.

Even if the next session were not the new session of a new Parliament, the committee would require to be appointed, but having regard to the fact that it is a new Parliament, it is possible that some change in the personnel of the committee will arise, when a similar committee is again appointed, as presumably will be the case.

The intentions of the Government as to the Royal Commissioner are not known. Whether the Government have decided to nationalise the railways or not, it seems clear that the Government control over railways will not be relaxed, although it may take a different form from the present.

Thus, during the election campaign, the Government have arranged an 8-hour day for many classes of railway servants, and Mr. Churchill has stated that he has arranged with the Railway Executive Committee and with the Board of Trade, to place, if necessary, orders for 1,000 locomotives and 30,000 or 40,000 wagons.

It seems desirable that under these circumstances, the traders of the country who contribute so largely to railway revenue, should give some expression of their views and desires with regard to the future control of the railways.

The Federation of British Industries recently appointed a Transport Committee, which has been giving a great deal of attention to the subject of transport, in all its bearings. The section of the committee dealing with railways, have in preparation, a Bill for submission to the executive of the federation, and it is hoped for eventual introduction to Parliament, which would be applicable whether the economic ownership of the railways rests in the shareholders of the individual railway companies or in the State.

This Bill deals with the control of the railways, that is, it reforms and extends the powers of the present Railway and Canal Commission Court, and it does so in the shape of a Railway Control Board.

This Board, in addition to acting upon its own initiative, ordering facilities and fixing rates, would be of a judicial character and would be the ultimate Court of Appeal from any decisions or any actions taken in connection with the working of the railways, whether the railways were worked under an united management or whether they were worked as of old under the control of Boards of the different railway companies, so that any trader who was aggrieved would have his present position preserved to him through a Board of Control, which would have wider and much more effective powers than the present Railway and Canal Commission Court has.

Such body must, of course, be quite distinct from the Management Committee or committees which would deal with the day-to-day administration of the railways.

The constitution of such Management Committee or committees is one that requires careful consideration, and is not dealt with in this memorandum.

It would probably take some little time to obtain consensus of opinion as to the constitution of this Management Committee or committees, and in the interim it would seem desirable that the State should continue the present principle of guarantee on the 1913 basis and that a Board of Control, such as has been described, should be established.

A lengthy discussion having taken place, revolving round the facts brought out in the above memorandum, the following resolutions were unanimously passed by the conference.

1. The manufacturers and traders of the country as represented by the Federation of British Industries, the Association of Chambers of Commerce, the Mansion House Association on Railway and Canal Traffic, the Traders' Traffic Conference and other trade associations represented at this meeting, in agreement with the view expressed by the Prime Minister of the importance of expeditious and economical transport to the trade of the country, desire to assure the Government that it may reckon upon the co-operation of the business community in any well-considered proposals to add to and to improve the transport facilities of this country.

2. That before the country is committed by the Government to any change of policy in regard to railways, it is desirable that the Royal Commission appointed some time since to consider the question should complete its investigation, or that a Select Committee should be appointed to continue the inquiries commenced by the Select Committee of last year, and that such report or Reports should be available before action is finally taken by the Government, and that it be an instruction to such Royal Commission or Select Committee that its report should be available by June 30 next.

3. That this meeting is unanimously opposed to nationalisation of the railways, and considers that in any form of control which it may be decided to adopt the Government should not in any case be concerned with the detailed administration of the railways of the country.

4. In the opinion of the bodies here represented it is desirable that the powers of the present Railway and Canal Commission Court should be extended and be vested in a Board of Control consisting of persons of experience in matters pertaining to transport, and that the majority of these persons should be appointed by the Secretary of State for the Home Department from a list submitted by a Joint Committee of representative associations concerned with trade.

5. That pending other arrangements being made by the State with the railway companies, the State should continue its present guarantee to the railway companies controlled by it.

6. That this meeting is of the opinion that the Government should be asked to instruct the Railway Executive to remove the many restrictions imposed, and reinstate all facilities withdrawn during the war.

BALL BEARINGS.—In reference to the following Order made by the Minister of Munitions, namely: The Ball Bearings Order, 1917, dated November 1, 1917, the Minister of Munitions now orders as follows: (1) The operation of the said Order is suspended on and after January 7, 1919, until further notice. (2) Such suspension shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such suspension or any proceeding or remedy in respect of such penalty or punishment.

BRITISH EMPIRE HONOURS.

A LONG list of appointments in, and promotions to, the Most Excellent Order of the British Empire (Civil Division) for services in connection with the war are announced in *The London Gazette* dated January 8. We give the names, as far as they can be recognised, of those who are engineers or have received honour for engineering work.

G.B.E.

Sir Charles Edward Ellis, K.C.B., Member of Ministry of Munitions Council and Representative of the Ministry in France and Italy; previously Director-General of Ordnance Supply; late Managing Director, Messrs. John Brown & Co., Ltd.

K.B.E.

Mr. Cecil Lindsay Budd, C.B.E., Member of Non-Ferrous Materials Department, Ministry of Munitions; Chairman of the Copper Committee and British Representative on the Inter-Allied Non-Ferrous Materials Committee. Mr. James Carmichael, J.P., Chairman of the Munition Works Board and of the Building Materials Supply Committee; Member of the Surplus Government Property Disposal Board. Sir Alfred Eyles, K.C.B., late Accountant-General of the Navy. Mr. William John Jones, C.B.E., Member of Iron and Steel Production Department, Ministry of Munitions. Mr. John McLaren, J.P., Chairman Board of Control, National Ordnance Factories, Leeds, Ministry of Munitions; Chairman of Messrs. J. & H. McLaren, Midland Engine Works, Leeds. Lieutenant-Colonel John Herbert Mansell, D.L., Managing Director, Coventry Ordnance Works. Mr. William Jackson Pope, C.B.E., F.R.S., D.Sc., LL.D., Member of the Chemical Warfare Committee, Ministry of Munitions; Professor of Chemistry Cambridge University. Mr. Aubrey Strahan, F.R.S., Sc.D., LL.D., Director of the Geological Survey of Great Britain and of the Geological Museum. Mr. William Thom, Chairman, Blackburn Board of Management, Ministry of Munitions; Member of the Engineering Trades (New Industries) Committee of the Ministry of Reconstruction; Director of Messrs. Yates & Thom, Ltd. Mr. John Wormald, Chairman of the General Service and Industries Committees, War Priorities Committee; Managing Director, Messrs. Mather & Platt.

C.B.E.

Mr. George Henry Banister, Special Director, Messrs. Vickers, Ltd. Major John Lawrence Benthall, T.D., Director, Messrs. Vickers, Ltd. Mr. George Christopher Clayton, J.P., Director, The United Alkali Co., Ltd. Mr. John William Cobb, Livesey Professor of Coal, Gas, and Fuel Industries, Leeds University; Deputy Inspector of High Explosives, Ministry of Munitions, Leeds Area. Mr. George Francis Dixon, Marine Superintendent, South-Eastern and Chatham Railway. Mr. James Clerk Maxwell Garnett, Principal, Municipal College of Technology, Manchester. Mr. Gerald Edward Chadwyck-Healey, Director of Materials and Priority, Admiralty. Mr. David Wilson Hood, Engineer-in-Chief, Trinity House. Mr. James Donald Keay, Engine Works Manager, Messrs. Harland & Wolff, Ltd. Mr. William Walker Lackie, Chief Engineer, Glasgow Corporation Electricity Department. Mr. Dudley Sinclair Marjoribanks, Local Director, Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd.; Vice-Chairman, Engineering Employers Advisory Committee. Mr. Thomas Graham Menzies, Director of Special Construction, Civil Engineer-in-Chief's Department, Admiralty. Mr. Charles Augustus Oliver, Assistant Director of Navy Contracts. Mr. Standen Leonard Pearce, Chief Engineer and Manager, Manchester Corporation Electricity Department. Captain Geoffrey Kelsall Peto, Director of Projectile Contracts, Ministry of Munitions. Mr. Alexander Whitehead Sampson, Director of Auxiliary Vessels, Admiralty. Mr. William Barbour Shaw, Director, Factory Construction Department, Ministry of Munitions. Mr. Robert Patrick Sloan, Managing Director, Newcastle Electric Supply Co., Ltd. Mr. James Bruce Strain, Deputy Controller, Department of Gun Ammunition Filling, Ministry of Munitions. Mr. Lionel Ashton Piers Warner, Deputy General Manager, Mersey Docks and Harbour Board; Director of Ports Branch, Ministry of Shipping. Mr. John William White, Committee on Production. Mr. William Francis John Wood, J.P., Chairman and Managing Director of the Derby Crown Glass Company, the Rylands Glass and Engineering Co., Ltd., Wood Bros. Glass Co., Ltd., &c.

India.—Mr. Frederick Warner Allum, Engineer-in-Chief, Nushki Extension Railway. Mr. Victor Hope Boalth, Traffic Manager, North-Western Railway. Mr. William Falkiner Harnett, V.D., Locomotive and Carriage Superintendent, Eastern Bengal State Railway.

O.B.E.

Mr. Harold Cholmley Mansfield Austen, Superintending Engineer, Department of Engineering, Ministry of Munitions. Mr. William Rebotier Aveline, Chief Engineer, Asiatic Petroleum Company, Limited. Mr. Alfred Watson Booth, Managing Director, Messrs. J. Booth and Sons, Rodley, Leeds. Captain Henry Frank Bourdeaux, Assistant Submarine Superintendent, Post Office Engineering Department. Mr. Percy Dale Bussell, Acting Assistant Director of Navy Contracts, Admiralty. Mr. George Tanner Chivers, Head Master, Dockyard School, Portsmouth. Mr. Albert Edward Cocks, Naval Store Officer, H.M. Dockyard, Devonport. Mr. Charles Henry Colson, Superintending Civil Engineer, Civil Engineer-in-Chief's Department, Admiralty. Mr. Maxwell Arthur Crosbie, Head of Machinery Department, Messrs. Boots and Co. Mr. Thomas Curr, Engineer and Manager, South Metropolitan Gas Company. Mr. Thomas Davies, Managing Director, Messrs. T. Davies and Sons, Limited. Captain Kenneth Randall Davis, Secretary, Birmingham Small Arms Company, Limited. Mr. James Johnstone Esplen, Director, Technical Department, British Ministry of Shipping in U.S.A. Engineer-Commander Anthony Ferguson, R.N.R., Chief Engineer of the Transport Olympic. Mr. Louis Ferguson, Senior Partner and Managing Director, Messrs. Ferguson Bros., Limited, Port Glasgow. Mr. William Fife, Senior Partner, Messrs. W. Fife and Sons. Mr. Hamilton Fulton, Managing Director, Messrs. Martinsyde, Limited. Lieutenant John Campbell Gardner, Assistant Superintendent (Guns) at a National Factory, Ministry of Munitions. Mr. Thomas Richard Gleghorn, Secretary, Central Iron Ore Committee, Ministry of Munitions. Mr. John Good, Assistant Controller, Gun Ammunition Manufacture Department, Ministry of Munitions. Mr. Clarence Noel Goodall, Managing Director, Messrs. Robert Stephenson Co., Limited. Mr. Frederick Holt, Chemist, the Castner-Kellner Alkali Company, Limited. Captain Reginald John Wallis-Jones, Section Director, Iron and Steel Production Department, Ministry of Munitions. Mr. William Foord-Kelcey, Professor of Mathematics and Mechanics, Royal Military Academy. Mr. William Thomas Kendall, Chief Engineer of the Transport Khiva. Mr. John Macfarlane Kennedy, Superintendent, Government Rolling Mills, Ministry of Munitions. Mr. Lucien Alphonse Legros, Chief Technical Assistant, Dilution Section, Ministry of National Service. Mr. John Lewis, Chief Engineer, Mercantile Marine. Mr. Frederick Charles Lohden, Standard Ship Branch, Ministry of Shipping.

Mr. James Colquhoun Macfarlane, Manager, Howitzer Shop, Messrs. Wm. Beardmore and Co., Limited. Mr. Lauchlan Grant McFarlane, Assistant Manager, Messrs. Cammell, Laird and Co., Birkenhead. Major Murray MacLeod, Inspector of Filled Fuzes, Directorate of Inspection of Gun Ammunition (Supervisory), Woolwich Arsenal. Captain Arthur Timothy Marshall, Assistant Secretary, Department of Controller-General of Merchant Shipbuilding, Admiralty. Major Robert Hobart Mayo, Section Director, Aircraft Technical Department, Ministry of Munitions. Mr. William Miles, Section Director, Agricultural Machinery Department, Ministry of Munitions. Mr. George Pate, Managing Director, the Carron Company; Member, Edinburgh Munitions Board of Management. Engineer-Commander George Patterson, R.N.R., Chief Engineer of the Transport Aquitania. Mr. William Littlejohn Phillip, J.P., Joint Managing Director, Messrs. Spencer and Co., Limited. Mr. John Quayle, Chief Engineer, Mercantile Marine. Mr. John McLorinan Robb, Superintending Engineer-in-Charge of South Midland District, General Post Office. Mr. Joseph Sayers, Superintendent at one of H.M. Factories, Ministry of Munitions. Mr. William Taylor, Chairman and Managing Director, Messrs. Taylor, Taylor and Hobson, Limited. Mr. George Roger Thompson, Chief Engineer of the Transport Toronto. Captain Alfred William Vincent Trant, Marine Superintendent, Mercantile Movements Division, Admiralty. Mr. Samuel Thomas Turner, Inspector of Munitions Areas, Sheffield. Mr. William Ernest Stephen Turner, D.Sc., Secretary, Society of Glass Technology; Head of Department of Glass Technology at Sheffield University. Mr. John Urie, Section Director, Contracts Department, Ministry of Munitions. Mr. Richard Wake, Section Director, Small Arms and Machine Guns Department, Ministry of Munitions. Captain Ernest Maclagan-Wedderburn, D.Sc., Experimental Department, Ministry of Munitions. Mr. Harris Gregory Williams, Assistant to General Manager, Messrs. Armstrong and Co., Newcastle. Mr. William Nance Williams, Technical Adviser on Wages, Labour Regulation Department, Ministry of Munitions.

India.—Mr. Frederick Henry Addis, V.D., Carriage and Wagon Superintendent, Bombay, Baroda, and Central India Railway. Mr. Arthur Morton Bell, Carriage and Wagon Superintendent, Great Indian Peninsular Railway. Mr. George Blackstock, Managing Director, Messrs. Rowe and Co., Burma. Mr. Alfred James Chase, Locomotive Superintendent, North-Western Railway. Engineer Lieutenant-Commander James William Mineard Godden, Royal Indian Marine, Engineer in Charge of Factory, Bombay Dockyard. Mr. Sidney John Kendrick, Superintendent, Carriage and Wagon Department, East Indian Railway. Mr. Arthur Mort, Mining Manager, Khost Colliery, Baluchistan. Mr. Frederick James Page, Locomotive and Carriage Superintendent, Bombay, Baroda and Central India Railway. Mr. Ernest Alexander Scott, Signal Engineer, North-Western Railway, Lahore, Punjab. Mr. Colin Joseph Silvester, Inspector of Munitions, Calcutta. Mr. Rudolph Victor Symons, District Engineer, Great Indian Peninsular Railway, Bombay.

M.B.E.

Mr. Edgar Alcock, Director and Works Manager, The Hunslet Engine Company, Limited. Mr. Charles Henry Andrews, Civil Engineer, Department of the Administrator of Works and Buildings, Air Ministry. Mr. Matthew Mather Ascough, Chief Engineer, Mercantile Marine. Mr. Gilbert William Barton, Works Manager, Messrs. Henry Bessemer and Co., Limited. Mr. George Richard Battle, Acting Electrical Engineer, Invergordon. Mr. Harry Percy Baxter, Steelworks Manager, Messrs. Edgar Allen and Co., Limited. Mr. Joseph Binns, Manager, Ministry of Munitions Instructional Factory, Manchester. Mr. George Bourn, Manager with Coventry Ordnance Works, Limited. Mr. James Brown, Chief Engineer, Mercantile Marine. Mr. John Lawrence Butler, Chief Foreman, Breech Mechanism Shop, Messrs. Wm. Beardmore and Co., Limited. Mr. George Eskholme Buttenshaw, Sectional Engineer, Department of Engineering, Ministry of Munitions. Mr. Frederic Brandon Cheshire, Inspector at a National Shell Factory. Major Thomas Henry Church, late Works Manager at an Explosives Factory. For courageous conduct on the occasion of a serious fire. Mr. Howard Wilfred Crack, Technical Assistant, Iron and Steel Production Department, Ministry of Munitions. Mr. Edward George Dean, Machine Tools Department, Ministry of Munitions. Mr. Terence Armiston Stewart-Dyer, Inspecting Engineer in U.S.A., Railway Materials Department, Ministry of Munitions. Mr. Elias Ewen, Manager, Boiler Shop, Messrs. Swan, Hunter and Wigham Richardson, Limited, Newcastle. Mr. Henry Edward Farmer, Chief Architectural Assistant, National Shipyards. Mr. Reginald France, Deputy Superintendent, Tools and Gauges, at a National Factory, Ministry of Munitions. Mr. James Fraser, Outside Erector, Messrs. Sir Wm. Arrol and Co., Limited.

Mr. James Hutchison Glen, Manager of Dock and Repairs Department, Messrs. Vickers, Limited. Mr. Andrew Gray, Works Manager, The Lanarkshire Steel Company, Limited. Mr. George Frederick Greenham, Assistant Superintending Engineer, General Post Office. Mr. Herbert James Ireland, District Engineer, H.M. Office of Works. Mr. William Tudor Jones, Chief Inspector at a National Shell Factory. Mr. Edward Kay, Works Manager, Messrs. Thomas Firth and Sons, Limited. Mr. James Hutchinson Kennedy, Chief Draughtsman, Messrs. Hamilton and Co., Port Glasgow. Mr. William Watt Lumsden, Superintendent, Cordite Department, at one of Nobel's Explosive Company's Factories.

Mr. Thomas McPherson, Chief Draughtsman, Wallsend and Slipway Engineering Company. Captain Herbert Medcalf, Works Engineer, Royal Aircraft Establishment, Ministry of Munitions. Mr. Henry Edward Dilke Merry, Assistant Inspector of Guns, Birmingham District, Ministry of Munitions. Mr. Harold Roland Morgan, Manager of a National Shell Factory, Ministry of Munitions. Mr. Robert Richardson Mortimer, Chief Draughtsman, The Staveley Coal and Iron Co., Limited. Mr. William Sidney Pearce, Chief Inspector of Mines, Admiralty. Mr. William Heath Peek, Master of Works at a National Projectile Factory. Mr. Edward Llewellyn Pickles, Chief Examiner to the Air Inventions Committee. Mr. Edmund Arthur Norman Pochin, Manufacturer of Rifle Gauges. Major Frederick Ernest Pollard, Sub-Section Director, Technical Department, Aircraft Production, Ministry of Munitions. Mr. Richard John Prichard, Chief Engineer of the Transport Greenore. Mr. Herbert Charles Pride, Works Control, Shell Factory, Messrs. White, Allom and Co. Mr. Vernon Proctor, Assistant Works Manager at one of Messrs. Cammell Laird and Co.'s Works.

Mr. James Ramsay, Manager, Erith Works, Messrs. Vickers, Limited. Mr. Francis Bartlett Richards, Assistant Superintendent (Works), Government Rolling Mills, Ministry of Munitions. Mr. Herbert Wheatley Ridsdale, Manager of Whitehead Torpedo Factory, Weymouth. Mr. John Albert Edgar Rusten, Chief Engineer, Mercantile Marine. Mr. Daniel Benjamin Sheriff Savile, Chief Engineer on Post Office Cable Ship Monarch. Mr. Richard Edward Skipwith, Technical Assistant to Director of Army Contracts. Mr. Lewis William Smith, Chief Foreman, Howitzer Shop, Messrs. Wm. Beardmore and Co., Limited. Mr. Henry Wilkinson Solly, Chief Engineer of the Transport Jabiru. Mr. William Lees Stenning, J.P., Works Officer, Timber Supplies Department. Mr. George Douglas Stevens, Manager, The Chilworth Gunpowder Company, Limited. Mr. Arnold Stevenson, Chief Chemical and Technical Assistant in the Optical Munitions Department, Ministry of Munitions. Mr. James Stewart, Chief Engineer of the Transport Boukadar. Mr. Swinton Stoddart, Chief Draughtsman, Messrs, Thompson and Sons, Sunderland. Mr. John Teasdale, Chief Draughtsman, Messrs. Hawthorn, Leslie and Co., Newcastle-on-Tyne. Mr. John Thomson, Works Manager, Messrs. Sir William Arrol and Co., Limited. Captain Lionel Arthur Frederick Verge, Assistant Inspector, Gun Ammunition (Supervisory), Woolwich Arsenal. Mr. William Hart Waddingham, Chief Designer, Elswick Ordnance Works. Mr. Albert George Williams, Principal Observer, Optics Division, National Physical Laboratory. Mr. William Henry Williams, Managing Director, The Aston Chain and Hook Company, Limited.

India.—Mr. Henry Armitstead, Deputy Superintendent, Carriage and Wagon Department, North-Western Railway. Mr. Rendall Hamilton Dennis, Assistant to Chief Engineer, Bengal and North-Western Railway, Gorakhpur, United Provinces. Mr. John Ruskin Phillips, Locomotive and Carriage Superintendent, Burma Railways. Mr. William Jameson Tomes, Deputy Locomotive Superintendent, Jamalpur, East Indian Railway.

LAND FOR BUSINESS USES.—The Ministry of Reconstruction have now issued the second report of the committee upon the acquisition and valuation of land for public purposes, of which Mr. Leslie Scott, K.C., M.P., is chairman. In this, the committee devote attention to a suitable system for the valuation of land compulsorily acquired for public purposes.

THE POTASH INDUSTRY OF ALSACE.—In our issue of December 27, we mentioned four large German alkali groups as being interested in the potash deposits of Alsace. We now learn from the Ligue Patriotique des Alsaciens Lorrain that one of these firms, the St. Thérèse Alkali Works Company, has no connection with German financiers. The German element is also being gradually eliminated from the others.

COAL-HANDLING PLANT AT THE COVENTRY CORPORATION ELECTRICITY WORKS.

MESSRS. ED. BENNIS AND CO., LIMITED, ENGINEERS, LITTLE HULTON, BOLTON.

Fig. 12.

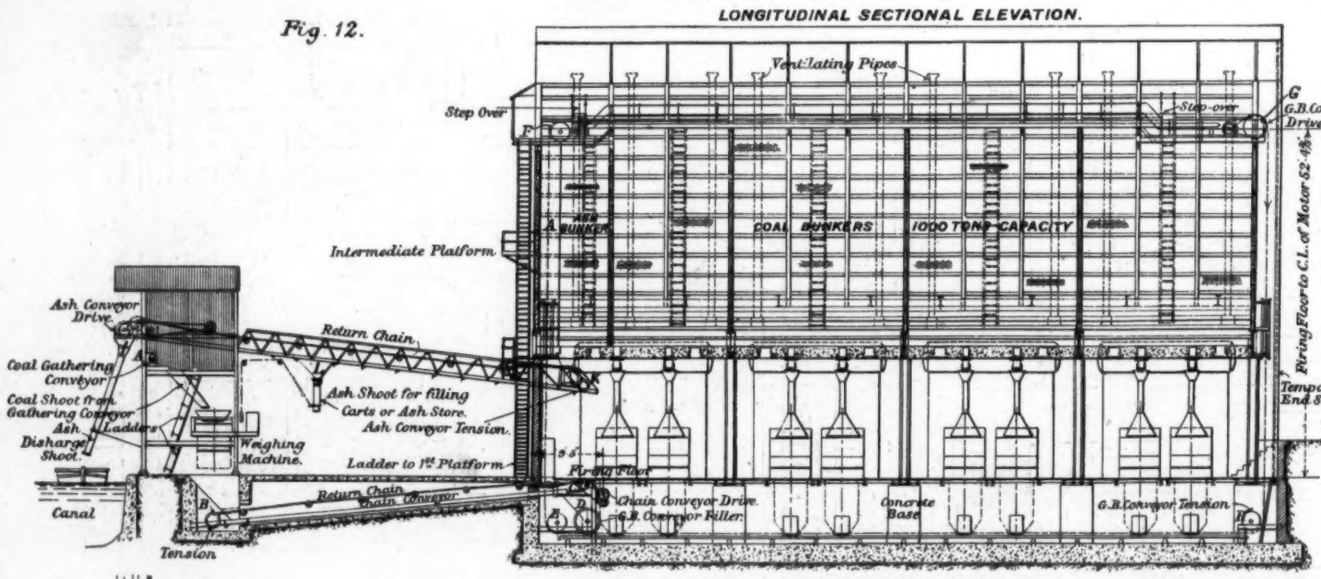


Fig. 13.

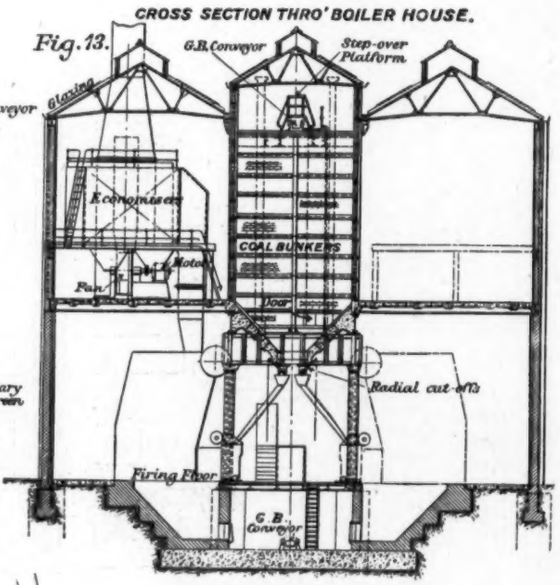
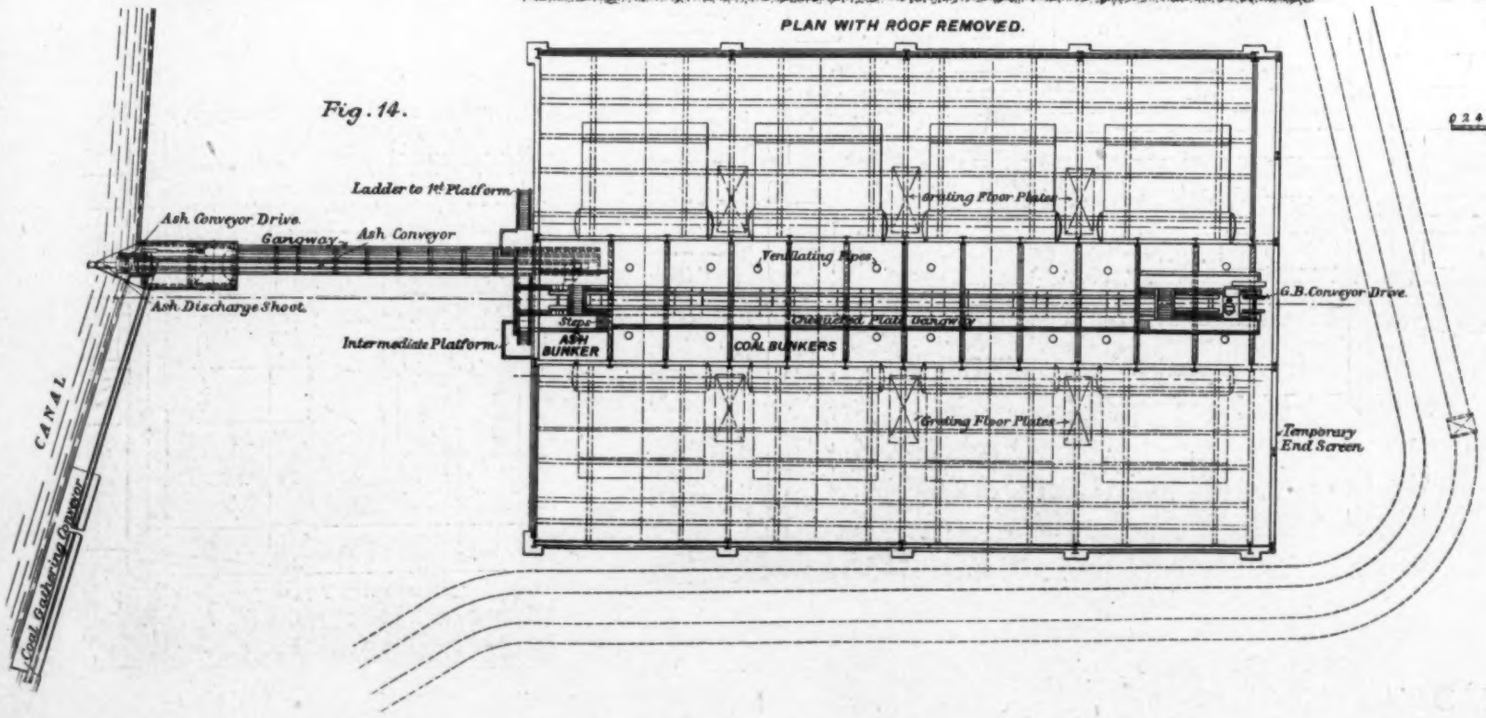


Fig. 14.

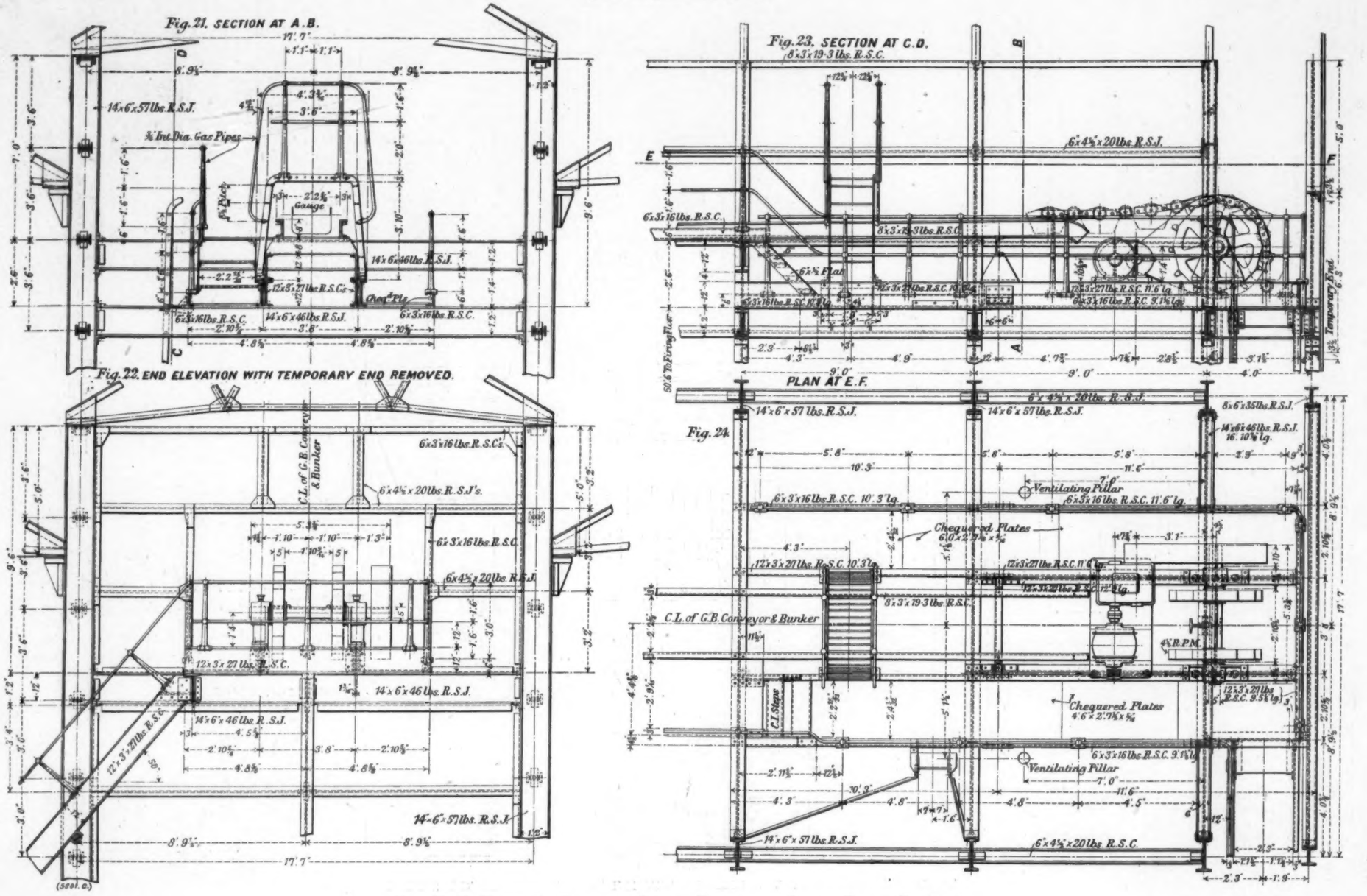


FIGS. 12, 13 AND 14. SECTIONS AND PLAN OF LATEST BOILER HOUSE.

COAL-HANDLING PLANT AT THE COVENTRY CORPORATION ELECTRICITY WORKS.

MESSRS. ED. BENNIS AND CO., LIMITED, ENGINEERS, LITTLE HULTON, BOLTON.

(*For Description see Page 37.*)



FIGS. 21, 22, 23 AND 24. DETAILS OF DRIVING TERMINAL OF GRAVITY BUCKET CONVEYOR.

(*To face page 39.*)

AIR FLOW THROUGH POPPET VALVES.*

By CLARKE THOMSON RESEARCH.

THIS discussion deals particularly with the merits of inlet valves in pairs, as compared with the single inlet perhaps more commonly used. The experimental data presented afford a direct comparison of valves singly and in pairs of different sizes, tested in a cylinder designed in accordance with current practice in aviation engines. Unfortunately, necessity limited the investigation to measurements taken under conditions of continuous flow.

This investigation was undertaken after a wholly unprofitable search for accurate information upon the comparative flow characteristics of single and double inlet valves, based upon actual measurement rather than upon some hypothesis, itself largely a matter of opinion.

By way of preliminary analysis, the application of the law of geometrical similarity presents a strong case for valves in pairs. For example, at a given pressure drop and the same lift, one valve would require a diameter of 4 in. to provide an area of opening equal to that of a pair of valves each of 2 in. diameter. The superficial area of the one 4-in. valve is twice the combined area of the two 2-in. valves, and if opened against a pressure in the cylinder, this is a measure of the comparative forces involved. The 4-in. valve would weigh four times the combined weight of the 2-in. pair, and the necessary spring tension would differ in that proportion, for the same lift and the same engine speed. It may be noted here that, while the above is correct upon the assumption of geometric similarity, the effective valve areas differ from the actual, as the coefficient of efflux varies at different lifts; also, that the weight of a well-designed valve increases somewhat less than the third power of the diameter would indicate.

Mr. H. L. Pomeroy† in a discussion which he states is wholly analytical, reaches a conclusion decidedly at variance with the above. Briefly stated, he assumes that two valves of 2·83 in. diameter should be substituted for one of 4 in. diameter (equal cross-sectional port area which requires that the smaller diameter be 0·707 of the larger diameter) and that the valves in each case are lifted 31·65 per cent. of their respective diameters. He then computes the hydraulic mean radii for the two cases, applies the laws of friction, and reaches the conclusion that the two valves would have a frictional resistance 39 per cent. greater than the single valve.

The contrast is sharp. The tentative conclusion geometrically derived is that two valves of one-half the cross-sectional port area and equal opening area, as compared to the single valve would afford the same flow. Mr. Pomeroy's tentative conclusion is that two valves having the same cross-sectional port area as the single valve, and the same opening area with a lift 0·707 that of the single valve, would have a frictional resistance 39 per cent. greater, and therefore less capacity. This discrepancy seemed to afford ample ground for experimentally determining the relative flow in similar combinations of valves.

This work was carried on by the Clarke Thomson Research in connection with problems involving exhaust gas scavenging at the Bureau of Standards and under the general direction of the National Advisory Committee for Aeronautics. Appreciation of the many courtesies extended by the Bureau of Standards is gratefully acknowledged.

Apparatus.—The apparatus consisted principally of a centrifugal blower, a model cylinder, and U-tubes for measurements of pressure.

The blower was one of special design with a balanced rotor 11·25 in. in diameter, composed of 10 forward curved blades. An electric motor furnished the power, rheostat control permitting speeds from 3,000 r.p.m. to 6,500 r.p.m., corresponding approximately to pressures of 9 in. to 32 in. of water. The number of impulses varied from 30,000 to 65,000 per minute, affording practically continuous flow. The blower was connected to the cylinder with rubber hose, care being taken to see that the alignment of the hose remained perpendicular to the face of the cylinder at point of entrance throughout the tests.

The cylinder is shown in longitudinal cross-section in Fig. 1. The cylinder head was carved out of white pine by an excellent pattern maker, and carefully finished as to its interior in accordance with dimension drawings. At the entrance end, the passages leading to the valves were cylindrical in form with axis perpendicular to the cylinder axis and 2·5 in. in diameter, the passages then curved as shown to the ports. The approach to the large valve, which had a diameter of 2·5 in., was circular in cross-section at all points. The approach to the pair of valves on the opposite side of the cylinder became narrower in the plane of the cross-section shown, and widened laterally to divide smoothly, about 1·5 in. from the ports, into two passages of 1·75 in. diameter. The angle between the valve axis and the cylinder axis was 15 deg. No valve guides or bushings extended into the passages.

The diameter of the counterbore was 5·75 in. and of the cylinder proper, 5 in. The valves were seated with a bevel of 30 deg. in the two planes forming the cylinder head. The diffuser shown was constructed of thin brass soldered together and inserted so as to divide the whole area of the cylinder at that point into rectangular passages about ¼ in. square and 2 in. long.

The jet at the opposite end of the cylinder was likewise carved out of white pine as shown, and was connected to the cylinder head by a length of 5-in. wrought-iron pipe, smoothly galvanised inside, used to obtain sufficient length for rectification of the air current. Gaskets and shellac were used at the joints and the assembly drawn together with four long bolts extending from end to end, outside the cylinder.

In addition to the single valve with a diameter of 2·5 in. and the pair of valves with diameters of 1·75 in. already mentioned, another pair with diameters of 1·25 in. was tested. False seats were used with this smaller pair, consisting of turned hardwood rings, carefully fitted to the 1·75-in. seats and bevelled to receive the smaller valves as shown in Fig. 4, page 62.

These false seats obviously left a circular shelf or projection 0·25 in. wide immediately above the ports. As a matter of interest, two readings were taken with these shelves projecting above the port, but before running off the main test on these 1·25-in. valves, the lines of the passages were smoothed off by filling in above these projections with putty, giving the approximate stream lines shown.

The valves were all designed on similar lines with the exception that the smallest pair had stems $\frac{1}{16}$ in. in diameter, to fit the guides used for the larger pair, this dimension being 40 per cent. larger than true proportion dictated, equivalent to a reduction of 0·022 sq. in. or 1·8 per cent. of the port area of the smaller pair.

The Pitot tube shown in the jet in Fig. 1 was clamped in position at the axis of the jet throughout the tests, velocity readings being taken as later described. The dimensions were $\frac{1}{16}$ in. outside diameter and about 2·5 in. in length. The impact end was gradually rounded and the static holes were four in number, about 0·02 in. diameter, smoothly perforating the outer wall.

A static tube of ¼ in. diameter penetrated the central portion of the cylinder, reading static pressure of the air column after passing the valves and the diffuser. This is for convenience termed the "lower static."

Static tubes of ¼ in. diameter also tapped the flow where the air column entered the passage leading to the valves. These are for convenience termed "upper static," only one being used at a time, as indicated by its position with respect to the valves. All statics were slightly rounded on the inner periphery, and the end kept flush with the inner surface of the cylinder or passage, and so located as to be perpendicular to the direction of air flow.

The upper and lower statics were connected to the two legs of a U-tube to read directly the pressure drop through the valve, and also connected to other U-tubes to read the upper static and lower static head separately.

All U-tubes had an inside diameter of about 0·25 in. and were vertical with the exception of one, which was inclined at a slope of 10 to 1 to read with greater accuracy velocity pressures of 3 in. or less.

A centigrade thermometer was clamped with its bare bulb in the air jet at a point about 1·5 in. outside the apparatus. A similar thermometer was hung on the wall for readings of room temperature.

The moisture content recorded is the average for the period indicated, as taken from a recording hygrometer, the variations being but slight, as were those of the barometer. All readings were completed within a period of 7½ hours, on May 23, 1918.

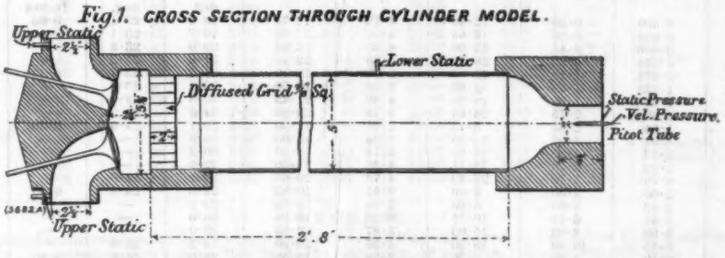
Measurement of Air Flow.—The method used for measuring the velocity and quantity of air is based upon the principles of the impact tube and the jet.*

Briefly, the impact tube, when held in and parallel to the air stream, registers a pressure corresponding to the total energy in the air at that point. In case of continuous flow through a pipe of varying cross-section, if the impact tube is moved up the axis of the air stream, the pressure registered is constant at all points, except for friction losses. The velocity pressure and static pressure vary with every change of cross-section, but the sum of the two, which the impact tube reads, is constant at all points, as the law of conservation of energy indicates.† This is similar to Bernouilli's theorem in hydraulics.

Where the section of the pipe is smaller, the velocity of the air must be higher, as the quantity passing all sections of the channel in a given time is constant under conditions of continuous flow. Higher velocity means greater kinetic energy in the moving air particle, and this increment can only arise out of a corresponding diminution of the static pressure.†

The jet here used for flow measurement carried this case further, contracting the air column to about one-

Fig. 1. CROSS SECTION THROUGH CYLINDER MODEL.



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* Report made to the United States National Advisory Committee for Aeronautics.

† "Engine Design," H. L. Pomeroy, in *Automobile Engineering*, June, 1912: Consider one 2½-in. valve and two 1¼-in. valves of equal area.

Let radius of port = r
valve lift = h
port area = πr^2
Valve opening = $2 \pi r h$

If V = velocity of gas through port
and V_1 = velocity of gas through valve opening
then

$$V_1 = \frac{V r^2}{2 r h} = \frac{V r}{2 h}$$

$$\therefore \quad \frac{V}{V_1} = \frac{2 h}{r} \quad . \quad . \quad . \quad (1)$$

Frictional resistance is proportional to the square of the velocity.

$$\text{Friction} = F = \frac{K L S V^2}{A}$$

Where S = Perimeter.
A = Area.
L = Length.
V = Velocity.

$$\therefore \quad \text{for the port } f = \frac{K L V^2 2 \pi r}{\pi r^2} = K \left(\frac{2 L V^2}{r} \right)$$

$$\text{for the valve opening } f_1 = \frac{K L V_1^2 4 \pi r}{2 \pi r h} = K \left(\frac{2 L V_1^2}{h} \right)$$

if $f = f_1$

$$\therefore \quad \frac{2 K V^2}{r} = \frac{2 K V_1^2}{h} \text{ or } \frac{V^2}{V_1^2} = \frac{r}{h}$$

from equation (1):

$$\frac{V}{V_1} = \frac{2 h}{r} \therefore \frac{V^2}{V_1^2} = \frac{4 h^2}{r^2} = \frac{r}{h}$$

or $$4 h^3 = r^3$$

or $$h = \frac{r}{\sqrt[3]{4}} = 0 \cdot 633 \, r$$

Assume both valves have a lift of 0·633 r:

Let L = length of pipe of port.
V = velocity of gas through port.
A = area of port.
S = perimeter of port = $2 \pi r$.
r = radius of port = 1·125.

$$f = K \left(\frac{L S V^2}{A} \right)$$

$$= K \frac{2 L V^2}{r}$$

$$= K \frac{K L V^2}{0 \cdot 5625} \text{ for a } 2\tfrac{1}{2}\text{-in. valve.}$$

for 1¼-in. valve, L and V are the same as before, but the hydraulic mean depth A/S

$$= \frac{2 \pi r^2}{4 \pi r} = 0 \cdot 405.$$

The friction in pounds per square inch is, therefore,

$$\frac{K L V^2}{0 \cdot 405}$$

Hence $$\frac{\text{Friction of double valve}}{\text{Friction of single valve}} = \frac{0 \cdot 562}{0 \cdot 405} = \frac{1 \cdot 39}{1}$$

or about 40 per cent. more.

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* An excellent discussion of the use of the impact tube and jet may be found in a paper entitled "The Impact Tube," by Mr. S. A. Moss, vol. xxxviii, Trans. A.S.M.E.

† It should not be understood that this conversion of energy (from static to velocity pressure and *vice versa*) takes place with 100 per cent. efficiency, as there is always a conversion loss due to generation of heat by surface and internal friction. In the case of convergence or reduction of area, the conversion loss is relatively much less, and the angle of convergence and "stream lining" of the conductor much less important than in case of divergence or increase in area. Convergence reduces static pressure and surface friction and produces a jet effect which rectifies the lines of flow and reduces or at least does not increase, eddy effects and internal friction. Divergence, on the other hand, increases static pressure and surface friction, and unless the angle of divergence be very small, results in conversion losses so large as to indicate great internal friction or eddying, probably in the nature of a rolling motion caused by large velocity differences at different radii. When the angle of divergence reaches 30 deg. on each side of the axis, the theoretical static gain is entirely eliminated by the conversion loss. An excellent discussion of conversion losses with experimental data and efficiency curves may be found in "Fan Engineering," pages 120 to 126, by Willis H. Carrier, member A.S.M.E. Much of the foregoing is quite elementary in character, but it appears that the characteristics of air flow are perhaps less generally understood than most branches of engineering data, and their treatment often seems more complex than illuminating, considered with respect to the average needs of the engineer.

(To face page 30.)

sixth of its area and discharging into atmosphere at a static pressure equal to atmospheric pressure, or zero U-tube reading, all energy in the air being kinetic, read as velocity pressure by the impact tube. This requires that the theoretical orifice be wholly convergent, i.e., that the ratio of absolute pressure of the region into which the jet discharges to the absolute pressure of the region from which the jet discharges be greater than the critical value, 0·5272, for air.

After verifying the fact that throughout the range of velocities used, the impact side of the Pitot tube at any given velocity showed constant readings for various positions in the jet, the Pitot was clamped in position, and readings from the impact side only recorded as velocity pressures. At frequent intervals during the runs the static side of the Pitot was tested, but invariably showed zero reading.

The velocity in the jet roughly equalled the velocity through the average valve opening, being about six times the mean velocity in the cylinder proper. In actual magnitude, the velocities ranged from 1,500 ft. to 19,000 ft. per minute, or 25 ft. to 320 ft. per second, covering about the extreme range of mean inlet velocities encountered in practice.

Table I shows actual and comparative dimensions and areas of the three valve combinations tested.

Diameters and port areas are computed upon the least diameter of the valve or port. In the case of the larger pair, it should be noted that the diameter of 1·75 in., used for convenience, gives an area about 2 per cent. less than that required by the geometrical relation for equal area, namely, $D\sqrt{0·5} = 0·7071\ D = 1·768$ in. diameter, for the pair to equal the area of the single valve.

The lifts used with each combination of valves were as follow: 0·05 in., 0·10 in., 0·20 in., 0·30 in., 0·40 in., 0·50 in., 0·75 in., 1 in. and 1·50 in. These valve lifts were carefully laid off and marked on the stems, and the settings made against fixed indicator points attached to the head of the cylinder. No screw thread or micrometer arrangement was used, and the probable error was relatively much greater at lower lifts. However, independent settings at low lifts checked within the limit of error of about 2 per cent. contemplated for the investigation as a whole. Adjustable clamps were used to hold the valves in position when set, and the readings taken covering the pressure range available.

After increasing the lift up to 1·5 in. with each valve combination, the valves were reversed; that is, the stems were clamped in the guides so as to project slightly through the ports, the valve heads remaining entirely outside the cylinder, and readings taken to determine the flow through the ports, eliminating the effect of the valve heads as baffle plates in the cylinder. It is often stated in works on design that lifting a valve about one-quarter of its diameter develops a valve area equal to that of the port. This is correct if limited to geometric relations, but seriously misleading if interpreted as providing a substantially equal effective orifice, as will later be developed in the experimental results.

Dr. C. E. Lucke, in his paper on "The Problem of Aeroplane Engine Design," presented at the May meeting of the American Society of Mechanical Engineers, 1917, makes the following statement concerning valve lift:—

"Coming now to the question of valves, everyone knows that it is of no consequence to lift a poppet valve more than one-quarter of its diameter. It is also true that the valve will work better, and the volumetric efficiency and mean effective pressure be better, the larger the diameter of the valve and the smaller the lift; that is, the valve should not approach the quarter-diameter lift. That condition conforms to good principles of gaseous flow."

Experimental Data.—Tables II, III and IV contain the data recorded in the tests of the three valve combinations. They are similar in form and refer, respectively, to the 1·75-in. valves, the 2·5-in. valve, and the 1·25-in. valves. The pressure readings are printed as read, in inches of water.

The readings of velocity pressure in the first column were partly taken on a U-tube inclined at a slope of 10 to 1, to facilitate more accurate readings of small quantities, but the decimal point is recorded so as to show pressures in inches of water, vertical head. Readings taken on the inclined tube are given to three places after the decimal point. After reaching the limit of this inclined tube at about 30 in., or 3 in. actual head, the remaining readings were taken on the usual vertical tubes. This column represents velocity pressure in the jet.

The second column shows the square root of the corresponding reading of velocity pressure in the first column, computed by slide rule. These amounts represent the relative velocities in the jet. The third column or lower static reading refers to the static pressure in the cylinder. Where these readings are small the probable error on account of capillarity or inequality in the tubes is rather large, but they were merely used for a rough check on the pressure drop through the valve tested, shown in the fourth column, which was read from a tube connected to both upper and lower statics.

The square root of pressure drop through the valve computed by slide rule, appears in the fifth column and is proportional to the theoretical mean velocity through the valve. A separate reading on the upper static appears in the sixth column, and the seventh and eighth columns show in degrees Centigrade the considerable variations of temperature with the velocity. The ninth column gives the valve lift, and the tenth column the coefficient of efflux, computed on valve areas equal to π Dh and assuming that the density of the air was atmospheric.

Graphical Comparison of Flow.—The data in Table II, covering the test of the pair of 1·75-in. valves at various openings and at various pressure drops, are shown graphically in Fig. 2, page 62, the data in Table III on the single 2·5-in. valve in Fig. 3, and the data in Table IV on the pair of 1·25-in. valves in Fig. 4. The purpose of this investigation was primarily to secure comparatively accurate comparisons as between the capacities of the different valve combinations, rather than to secure absolute quantitative determination of the flow in any case. It will readily be seen that the velocity and quantity of air flowing through the jet at the outlet of the system will be proportional to the square root of the velocity pressures read by means of the impact tube in the jet. The vertical scale of many of the following graphs is taken from the second columns of Tables II, III and IV, and is termed for convenience "Proportional flow." It is equally obvious that for accurate quantity determinations, corrections should be made for temperature, pressure, and humidity by the application of well-known thermodynamic formulæ, but this would appear an unnecessary and perhaps misleading refinement considering the general degree of accuracy here obtainable.

The horizontal scale is laid off to the square root of the pressure drop through the valve combination tested, which is deemed much preferable for the present purpose to the use of the pressure drop itself. With the limited range of pressures available, and the considerable variation in valve areas tested, the curves obtained by plotting to the pressure drop would be so distributed that no single ordinate would intercept all the curves.

The system used, however, produces straight-line graphs passing through the centre of co-ordinates, as the velocity through the valve is proportional to the square root of the pressure drop, for any given lift, and these graphs may, therefore, be extended to intercept any particular ordinate without appreciable error, which greatly facilitates the study of the results obtained.

If desired, the slope of each graph may be arithmetically determined by computing the average ordinate and the average abscissa for the points on any one line, applying suitable weights to any readings deemed of unequal value, the slope of the graph being fixed by the ratio of such averages.

Wherever "proportional flow" is used as a basis for plotting in the various diagrams shown, it should be remembered that this refers to flow through the same jet in all cases, without respect to the valve opening or pressure drop causing the flow, and that the various results so obtained may, therefore, be directly compared, owing to the use of this jet as the common medium of measurement in all tests.

As to these Figs. 2, 3 and 4, it is true that the scale is small, and that plotting to square roots tends to reduce the magnitude of any irregularities in the points obtained, but the close coincidence of the points with the straight graphs passing through the origin seems to warrant the conclusion that the actual velocity through the valve at any given lift varies directly with the square root of the pressure drop, at least within the limits of these tests, as does the theoretical velocity. It further follows as a general rule within these limits that the coefficient of efflux does not vary with the pressure drop. Certain limitations upon this conclusion may be required, however, and will be discussed in connection with the graphs showing the variation of the coefficient of efflux with the lift.

Curves of equal velocities have been superimposed upon the graphs of Figs. 2, 3 and 4 to show the approximate velocities through the valves in feet per second. At about the average conditions of the tests, namely, 80 deg. F., 55 per cent. humidity, 68 deg. wet bulb, and 29·72 in. barometer, air weighs 0·0717 lb. per cubic foot. Inserting this value in the equation $V = 18·275\sqrt{p/w}$ gives $V = 68·2\sqrt{p}$. In other words, assuming air at this density, multiplying the vertical scale by 68·2 gives actual velocity through the jet in feet per second, and applying the same correction to the horizontal scale gives theoretical velocity through the valves. The actual velocity through the valves may then be obtained either by applying the ratio of areas to the vertical scale of jet velocities or by applying the proper coefficient of efflux to the horizontal scale of theoretical valve velocities.

Curves representing actual velocities of 100 ft., 200 ft. and 300 ft. per second through the valves have been laid

TABLE I.

Valve Combinations.	Circumference of Ports in Inches.			Cross-sectional Area of Ports in Square Inches.		
	One Valve.	Total.	Total in per Cent. of 2·5-in. Valve.	One Valve.	Total.	Total in per Cent. of 2·5-in. Valve
			per cent.			per cent.
Two valves, 1·75 in. diameter..	5·498	10·996	140	2·405	4·810	97·8
One valve, 2·5 in. diameter	7·854	7·854	100	4·909	4·909	100·0
Two valves, 1·25 in. diameter..	3·927	7·854	100	1·227	2·454	50·0

TABLE II.

(Kind of measurement, air flow through poppet valves; instrument tested, two valves 1¾ in. diameter, continuous flow; date, May 23, 1918; humidity, 55 per cent.; barometer, 755 mm.)

Velocity Pressure.	Square Root Velocity Pressure.	Lower Static.	Pressure Drop.	Square Root Pressure Drop.	Upper Static.	Temperature.		Valve Lift.	Coefficient Efflux.
						Jet.	Room.		
						deg.	deg.	Inches.	
0·250	0·500	0·20	12·40	3·52	12·75	26·2	23·1	0·05	0·887
0·360	0·600	0·30	16·65	4·09	17·10	26·7	23·1	—	—
0·475	0·689	0·45	22·00	4·69	22·65	29·0	23·3	—	—
0·630	0·794	0·60	28·30	5·33	29·10	31·6	23·5	—	—
0·950	0·975	1·10	11·05	3·33	12·30	27·9	23·7	0·10	0·889
1·520	1·233	1·50	14·90	3·86	16·50	29·1	23·8	—	—
1·710	1·31	1·95	19·25	4·39	21·45	30·8	23·9	—	—
2·850	1·69	2·75	26·95	5·19	29·85	34·3	24·0	—	—
2·68	1·64	2·65	8·45	2·91	11·30	29·1	24·0	0·20	0·818
3·65	1·91	3·50	11·30	3·36	15·00	29·5	—	—	—
4·50	2·12	4·35	13·95	3·74	18·50	30·3	—	—	—
6·35	2·52	6·20	19·15	4·38	25·30	32·5	—	—	—
7·30	2·70	7·10	22·40	4·73	29·65	34·1	24·0	—	—
4·00	2·00	3·80	6·80	2·61	10·85	29·3	24·0	0·30	0·736
5·20	2·28	5·00	8·90	2·98	14·05	29·5	—	—	—
6·35	2·52	6·10	10·75	3·28	16·95	30·0	—	—	—
8·95	2·99	8·60	15·00	3·87	23·65	32·0	—	—	—
11·20	3·45	10·80	18·80	4·33	29·90	34·3	24·0	—	—
4·80	2·19	4·60	5·70	2·38	10·50	29·0	24·0	0·40	0·654
6·15	2·48	5·95	7·40	2·72	14·45	29·5	—	—	—
7·50	2·74	7·30	9·00	3·00	16·40	30·1	—	—	—
10·50	3·24	10·20	12·35	3·51	22·65	31·9	—	—	—
12·75	3·56	12·45	14·90	3·86	27·30	33·4	24·0	—	—
5·50	2·34	5·30	4·95	2·22	10·40	28·9	24·0	0·50	0·608
7·05	2·66	6·90	6·40	2·53	13·45	29·3	—	—	—
8·70	2·95	8·40	7·55	2·75	15·75	30·0	—	—	—
11·75	3·42	11·55	10·35	3·22	22·20	31·6	—	—	—
14·30	3·78	14·15	12·60	3·55	26·90	33·5	24·0	—	—
5·70	2·39	5·50	3·55	1·89	9·30	29·0	24·0	0·75	—
7·45	2·73	7·30	4·65	2·16	12·05	29·0	—	—	0·489
8·90	2·98	8·65	5·40	2·32	14·15	29·5	—	—	—
13·15	3·12	12·95	8·00	2·83	20·95	31·4	—	—	—
16·20	4·02	16·00	9·65	3·11	25·70	33·5	24·0	—	—
6·25	2·50	6·00	3·05	1·75	9·20	28·7	24·0	1·00	0·418
7·80	2·79	7·75	4·00	2·00	11·90	29·0	—	—	—
9·60	3·10	9·25	4·75	2·18	14·10	29·4	—	—	—
14·15	3·76	13·80	6·80	2·61	20·65	31·3	—	—	—
17·20	4·15	16·90	8·30	2·88	25·20	33·0	24·0	—	—
6·40	2·53	6·20	2·80	1·67	9·05	28·1	24·0	1·50	0·296
8·30	2·88	8·05	3·55	1·88	11·70	28·9	—	—	—
9·90	3·14	9·55	4·20	2·05	13·85	29·3	—	—	—
14·50	3·81	14·10	5·85	2·42	20·05	31·0	—	—	—
18·05	4·25	17·50	7·20	2·68	24·90	32·5	24·0	—	—
6·20	2·49	6·05	2·15	1·47	8·40	28·6	24·0		
8·20	2·86	8·00	2·80	1·67	10·85	28·8	—	Valve reversed.	—
10·50	3·24	9·65	3·40	1·84	13·15	29·4	—		
14·35	3·79	14·10	4·85	2·20	19·05	31·0	—		
17·55	4·18	17·10	5·90	2·43	23·00	32·7	24·2		

off by the former method and agree fairly with results obtained by the latter method, except as to irregularities in some of the points used for plotting the coefficient curves later presented.

sq. in., as required pressure drop, it should be noted that these velocity curves are merely approximate and that errors up to 5 per cent. or so may be found.

In Fig. 4, page 62, will be found an illustration of

TABLE III.

(Kind of measurement, air flow through poppet valves; instrument tested, one valve 2¼ in. diameter, continuous flow; date, May 23, 1918; humidity, 56 per cent.; barometer, 755 mm.)

Velocity Pressure.	Square Root Velocity Pressure.	Lower Static.	Pressure Drop.	Square Root Pressure Drop.	Upper Static.	Temperature.		Valve Lift.	Coefficient Efflux.
						Jet.	Room.		
						deg.	deg.	inches.	
0·140	0·374	0·15	12·60	3·55	12·90	29·0	24·6	0·05	0·96
0·225	0·475	0·25	17·10	4·13	17·40	30·8	—	—	—
0·370	0·608	0·35	23·20	4·82	23·70	32·6	—	—	—
0·435	0·660	0·45	25·75	5·08	26·20	34·3	25·0	—	—
0·505	0·710	0·65	11·35	3·36	12·25	31·2	25·0	0·10	0·95
0·840	0·915	0·90	15·50	3·94	16·60	32·0	—	—	—
1·200	1·097	1·25	20·60	4·55	22·00	33·3	—	—	—
1·655	1·290	1·70	27·75	5·27	29·50	35·6	25·0	—	—
1·690	1·30	1·70	9·55	3·09	11·50	31·4	25·1	0·20	0·856
2·330	1·53	2·35	12·90	3·59	15·40	32·0	—	—	—
3·020	1·74	3·00	16·60	4·07	19·60	33·0	—	—	—
4·000	2·00	3·85	20·85	4·56	25·40	35·2	—	—	—
4·750	2·18	4·50	25·00	5·00	29·65	36·3	25·1	—	—
2·70	1·64	2·55	8·35	2·89	11·10	31·2	25·3	0·30	0·756
3·55	1·88	3·40	11·15	3·34	14·80	31·6	—	—	—
4·55	2·14	4·40	14·30	3·78	18·85	32·4	—	—	—
5·80	2·41	5·70	18·40	4·29	24·20	33·8	—	—	—
7·25	2·69	7·00	22·50	4·75	29·80	35·6	25·3	—	—
3·70	1·92	3·50	6·85	2·62	10·60	30·8	25·6	0·40	0·728
4·85	2·20	4·70	9·15	3·02	13·95	31·2	—	—	—
6·05	2·46	5·90	11·45	3·38	17·40	32·1	—	—	—
7·85	2·80	7·65	14·75	3·84	22·40	33·5	—	—	—
1·020	3·19	9·85	18·65	4·32	28·20	35·8	25·6	—	—
4·40	2·10	4·20	5·60	2·37	10·00	31·3	25·6	0·50	0·710
5·80	2·41	5·60	7·40	2·72	13·20	31·5	—	—	—
7·30	2·68	7·00	9·25	3·04	16·40	32·2	—	—	—
9·55	3·09	9·30	12·10	3·48	21·50	33·6	—	—	—
11·85	3·49	11·45	14·75	3·84	26·00	35·2	25·6	—	—
5·40	2·32	5·20	4·20	2·05	9·60	28·9	25·8	0·75	0·605
7·15	2·67	6·95	5·50	2·34	12·55	30·1	—	—	—
8·90	2·98	8·60	6·80	2·61	15·45	31·4	—	—	—
11·90	3·44	11·55	9·05	3·01	20·70	33·5	—	—	—
14·70	3·83	14·10	10·80	3·28	24·20	35·2	25·8	—	—
5·80	2·41	5·60	3·75	1·94	9·50	31·3	26·3	1·00	0·509
7·70	2·78	7·40	4·90	2·22	12·40	31·8	—	—	—
9·60	3·10	9·25	6·05	2·46	15·40	32·6	—	—	—
12·90	3·59	12·45	7·95	2·82	20·45	34·3	—	—	—
15·20	3·90	14·30	9·05	3·01	22·50	35·3	26·3	—	—
6·10	2·47	5·90	3·30	1·82	9·40	31·8	26·6	1·50	0·373
8·10	2·85	7·90	4·30	2·08	12·25	32·2	—	—	—
10·05	3·18	9·80	5·35	2·32	15·30	33·0	—	—	—
13·50	3·67	13·20	7·05	2·66	20·45	34·5	—	—	—
15·80	3·98	15·00	7·85	2·80	22·20	35·5	26·6	—	—
6·35	2·52	6·15	2·70	1·64	9·05	31·5	26·6		
8·50	2·92	8·15	3·50	1·87	11·75	32·0	—	Valve reversed.	—
10·65	3·26	10·30	4·35	2·08	14·75	32·7	—		
14·40	3·80	14·00	5·85	2·42	19·85	34·1	—		
16·70	4·08	15·80	6·40	2·53	21·20	35·3	26·6		

TABLE IV.

(Kind of measurement, air flow through poppet valves; instrument tested, two valves 1½ in. diameter, continuous flow; date, May 23, 1918; humidity, 53 per cent.; barometer, 755 mm.)

Velocity Pressure.	Square Root Velocity Pressure.	Lower Static.	Pressure Drop.	Square Root Pressure Drop.	Upper Static.	Temperature.		Valve Lift.	Coefficient Efflux.
						Jet.	Room.		
						deg.	deg.	inches.	
0·140	0·374	0·20	12·65	3·56	12·90	30·8	27·0	0·05	0·90
0·230	0·484	0·27	17·45	4·18	17·80	32·5	—	—	—
0·350	0·591	0·40	24·10	4·91	24·60	34·5	—	—	—
0·420	0·648	0·45	26·35	5·13	26·85	36·0	27·0	—	—
0·570	0·755	0·65	11·40	3·38	12·05	34·0	27·1	0·10	0·92
0·840	0·917	0·85	16·35	4·04	16·00	34·5	—	—	—
1·120	1·060	1·10	20·10	4·49	21·35	35·5	—	—	—
1·440	1·200	1·40	25·60	5·06	26·10	37·5	27·1	—	—
1·230	1·11	1·20	10·50	3·24	11·85	33·5	27·1	0·20	0·691
1·750	1·32	1·70	14·40	3·79	16·25	34·5	—	—	—
2·330	1·53	2·30	19·25	4·39	21·70	36·0	—	—	—
2·930	1·71	2·95	23·90	4·86	26·60	37·0	27·1	—	—
1·940	1·39	1·90	9·35	3·06	11·30	34·0	27·2	0·30	0·613
2·650	1·63	2·55	12 60	3·55	15·35	34·3	—	—	—
3·550	1·88	3·35	16·50	4·06	20·00	35·0	—	—	—
4·400	2·10	4·20	20·55	4·54	24·75	37·0	—	—	—
5·200	2·28	4·70	24·20	4·92	29·20	39·0	27·2	—	—
2·50	1·58	2·30	8·90	2·98	11·40	34·5	27·2	0·40	0·528
3·35	1·83	3·15	12·00	3·46	15·35	34·7	—	—	—
4·35	2·09	4·10	15·70	3·96	19·90	35·5	—	—	—
5·30	2·30	5·30	20·10	4·49	25·65	38·5	—	—	—
6·25	2·50	6·05	22·20	4·71	28·25	39·0	27·2	—	—
2·70	1·64	2·50	8·50	2·92	11·30	32·0	27·5	0·50	0·459
3·75	1·94	3·55	11·55	3·39	15·10	33·5	—	—	—
4·80	2·19	4·70	15·15	3·89	20·00	35·0	—	—	—
5·85	2·42	5·75	18·40	4·29	24·20	36·5	27·5	—	—
3·10	1·76	2·95	8·35	2·89	11·45	33·5	27·9	0·75	0·327
4·05	2·01	3·90	10·80	3·29	14·80	34·3	—	—	—
5·20	2·28	5·05	14·00	3·74	19·20	35·3	—	—	—
6·60	2·57	6·40	17·70	4·20	24·05	37·0	27·9	—	—
3·10	1·76	2·95	7·80	2·79	10·90	34·0	27·9	1·00	0·254
4·20	2·05	4·00	10·45	3·24	14·60	34·6	—	—	—
5·75	2·40	5·60	14·25	3·78	20·00	35·5	—	—	—
7·10	2·66	6·90	17·65	4·20	24·60	37·3	—	—	—
3·35	1·83	3·20	7·90	2·81	11 25	34·0	27·9	1·50	0·174
4·35	2·08	4·10	10·25	3·20	14·45	34·3	—	—	—
6·00	2·45	5·85	13·60	3·68	19·30	35·6	—	—	—
7·10	2·66	6·90	16·50	4·06	23·50	37·0	—	—	—
3·35	1·83	3·15	7·50	2·74	10·90	33·5	27·9		
4·60	2·15	4·30	10·05	3·17	14·60	34·2	—	Valve reversed.	—
5·90	2·43	5·75	13·25	3·64	19·10	35·0	—		
7·25	2·69	7·10	16·20	4·02	23·35	36·5	—		

These curves may be used to approximate the actual pressure drop necessary to produce a given velocity. For example, in Fig. 2 it is seen that the pair of 1·75-in. valves with 0·20 lift indicates a velocity of 200 ft. per second at the ordinate corresponding to 3·55 in the horizontal scale or 12·6 in. of water or 0·455 lb. per

the manner in which a pair of 1·25-in. valves were seated in the cylinder for testing. The closely shaded sections represent the false seat of hardwood, and the dotted sections indicate the putty used to join the ports of the false seats smoothly to the passages.

Before making the putty joint as shown, two tests of purely collateral interest were made at 0·3 in. lift, to show the effect of the sharp ledge in the passage. The results are shown by the dotted line X Y, the flow being 13 per cent. less for any given pressure drop, than with the passage stream-lined as described. It is, therefore, evident that any projections or sharp angles in the passage tend greatly to reduce the flow, as might well be anticipated.

The very common custom of finishing the inlet passages with two bores meeting at an angle of about 110 deg. certainly puts a heavy restriction upon valve efficiency, but doubtless constructional convenience may be held to justify the practice.

Interesting experimental work could be done on the design of valve guides, possibly joining them to the wall of the passage with a web of stream-line section. Valves with an extremely heavy fillet have been used in the R.A.F. 3A engine, doubtless with the idea of guiding the air current smoothly to the valve opening. Venturi effects in the passage immediately above the valve might be productive of excellent results.

The use of the putty as above described to reduce the size of the passage to the diameter of the small valve, introduced a converging nozzle effect which doubtless tended to direct the air stream inward toward the valve stem and thereby slightly impair the efficiency of this small pair of valves.

It is evident that the intercepts on any ordinate on Figs. 2, 3 or 4 will represent the variation of the flow with the valve lift, at the pressure drop corresponding to the ordinate selected.

Fig. 5, page 62, presents such curves for the three valve combinations, plotted from intercepts on the ordinates corresponding to a pressure drop of 16 in. of water, the ordinates numbered 4 in the square root scale. The relation would have been the same had any other ordinate been chosen, but the quantities would have been different.

The curve of flow for the single 2·5-in. valve lies between those of the pairs of valves at all lifts. It is found to be very nearly equal to that of the smaller pair for low lifts, and approximates that of the larger pair at the higher lifts.

These curves are plotted against valve lift in inches, but for convenience the points equal to one-quarter and one-half diameter have been marked on each curve. By interpolation between these points and others similarly located, the approximate curve of flow for two valves of 1·5 in. diameter is presented. This indicates a flow quite closely equal to that of the single 2·5-in. valve, up to a lift of about 0·6 in.

The vertical intercepts of these four curves on ordinates corresponding to various valve lifts are compared in Table V, in percentages of the flow of the single valve.

The points connected to the curves by broken lines indicate, to vertical scale only, the flow with the valves reversed. This might be considered equivalent to the flow with the valves at an infinite lift, which agrees with the horizontal trend of the curves, but more practically, these points represent the maximum limit of flow through the respective ports at this pressure drop. These curves, comparing performance upon a basis of equal lift in inches, are particularly applicable where it is conceded that mechanical features generally limit the possible lift regardless of valve diameter.

On the other hand, it is often asserted that the proper limit of valve lift is a function of the diameter, and for purposes of comparison on this basis, Fig. 5a has been prepared from the curves last discussed, changing the horizontal scale to read in per cent. of the diameter of each valve. In the case of pairs of valves, the flow of both is plotted against the lift, expressed in per cent. of the diameter of one valve only.

The result of this transposition is at once apparent. The intercepts on any ordinate very closely agree with the proportionate cross-sectional port areas of the several valve combinations, and in the case of the two curves corresponding to valve combinations with equal cross-sectional port area, the curves coincide within the probable error of the work. Up to a lift of 0·5 diameter the coincidence is all the more exact if it be remembered that the two 1·75-in. valves have an area about 2 per cent. less than the single 2·5-in. valve.

From this it would appear reasonable to infer that under fairly similar conditions different valves or combinations of valves have capacities in proportion to their respective cross-sectional port areas, when the lift in each case is same per cent. of their respective diameters.

It also seems logical to infer that the theory of the hydraulic mean radius has but little application to the losses in poppet valves, it being more properly applicable to what may, for convenience, be termed surface friction or actual rubbing of the moving fluid upon the surrounding wall, whence its derivation—the relation of cross-sectional area to perimeter in contact with the moving fluid.

In the case of continuous flow through a pipe or conduit, pressure losses may be classified as friction losses and dynamic losses, although no sharp distinction can be drawn. Dynamic losses are due to change in direction, either of the whole column or its lesser parts, as at elbows, nozzles or offsets; and friction of the fluid against the walls undoubtedly causes a rolling motion with change of both direction and velocity in the adjacent particles. The change in direction at an elbow will cause a greater pressure with greater friction on the outer side. An easy-radius elbow is ordinarily estimated to cause a pressure loss equal to the friction loss in 10 diameters of straight pipe, but a right angle or mitred joint in the pipe will cause a loss equal to the friction loss in nearly 50 diameters.* It is thus evident that

* "Loss of Pressure Due to Elbows," Frank L. Busey, Proc. of Am. Soc. of Heating and Ventilating Engineers, 1913.

where marked changes in direction take place in a length of but two or three diameters, the dynamic losses may be many times as great as the losses due to friction, and the case of the inlet passage terminating in a poppet valve falls in this class.

As a rough comparison of probable friction loss and dynamic loss, it may be assumed that the friction in the passage and at the lip of the valve is equivalent to that of 5 diameters of straight pipe at the same velocity. From Mr. Busey's experiments dynamic losses might be expected equal to the friction loss in about 8 diameters due to the curvature of the passage, and further dynamic losses equal to the friction in at least 30 diameters due to the sharp change of direction at the valve seat, — 60 deg. at low lifts with a 30-deg. seat. If this comparison is within the limits of fair approximation, Mr. Pomeroy's 39 per cent. greater friction loss is only applicable to about 15 per cent. of the total loss, or about 6 per cent. less capacity would be expected from a pair of valves having 0·7 the diameter and 0·7 the lift of a single valve. From the data here obtained, it appears that the two valves have only about 2 per cent. less capacity at 0·7 the lift.

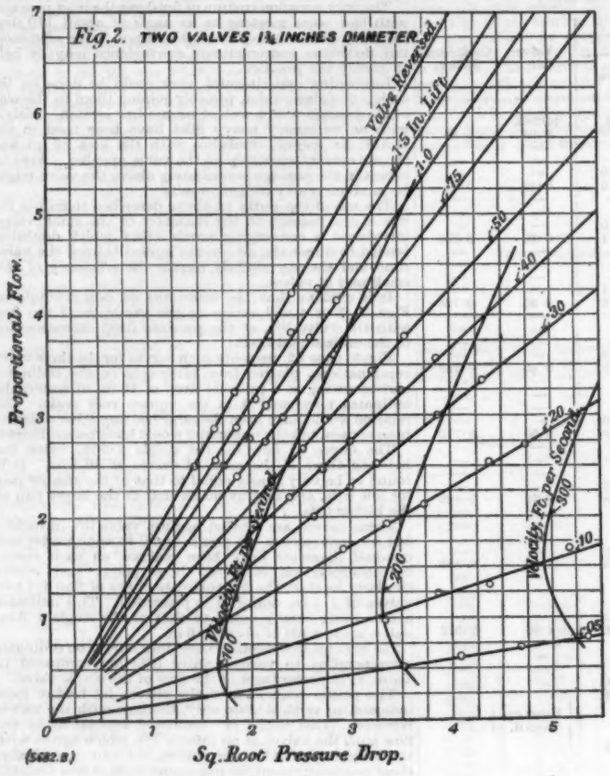
For ready comparison, Table VI has been prepared from the vertical intercepts on the curves of Fig. 2 below, showing the relative cross-sectional port areas and capacities in per cent. of the area and capacity of the single 2·5-in. valve, each valve being lifted the same per cent. of its diameter.

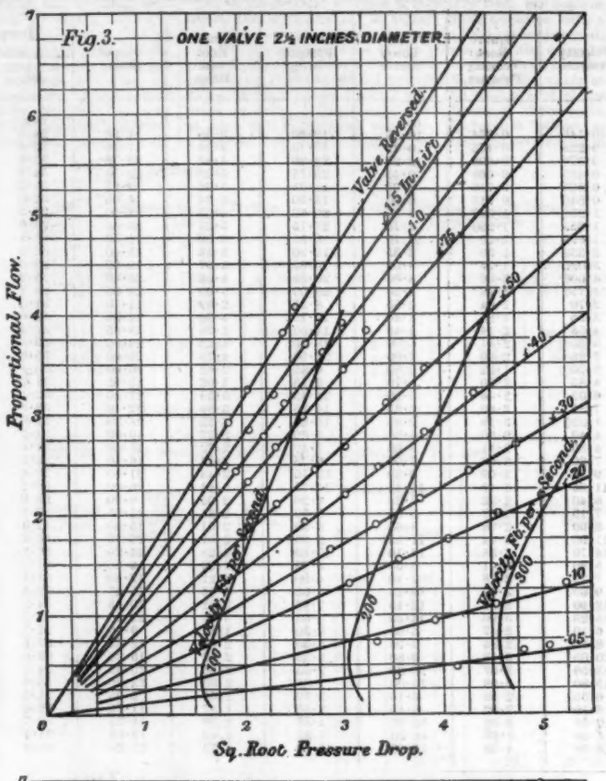
It is evident from an inspection of the curves on Figs. 5 and 5a that a lift equal to one-quarter diameter develops less than 67 per cent. of the full capacity of the port, and that a lift of one-half diameter develops 80 per cent. to 90 per cent. of the full capacity.

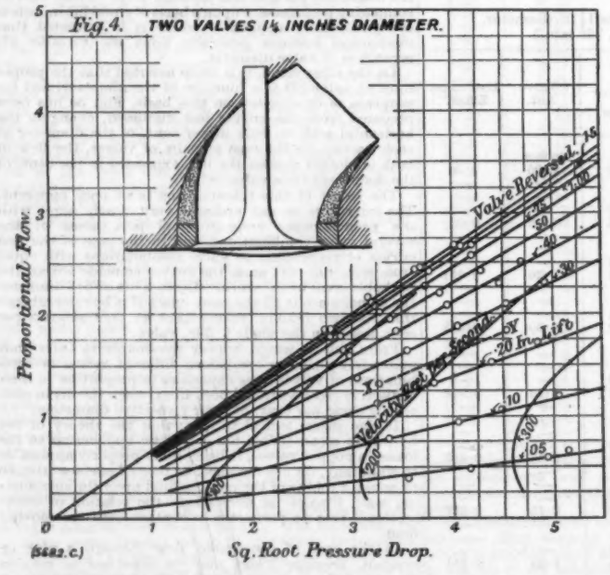
The coefficient of efflux is taken as the ratio of the observed mean velocity through the valve to the mean velocity which would theoretically result from an equal pressure drop. Assuming that the temperature, density and humidity of the air are the same at the valve as at the jet, this coefficient may be obtained directly from the relation of the areas and the proportional velocities set forth in Tables II, III and IV. The proportional velocity at the jet multiplied by the ratio of the jet area to valve area gives the proportional velocity through the valve. If the ratio of this velocity to the square root of the pressure drop be taken, the result is the coefficient of efflux. To be more exact, this should be multiplied by 0·99, the coefficient of the jet.

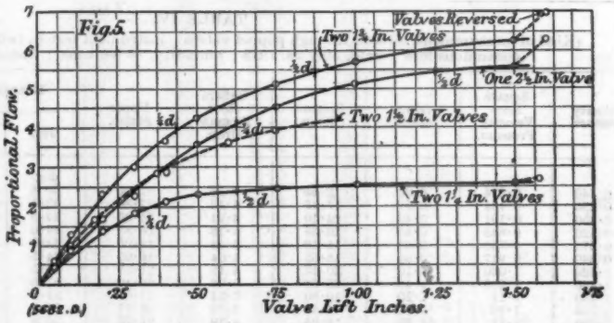
The above short method may be justified by developing the usual equation $V = \sqrt{2gh}$ in the units here most convenient:

V = velocity in feet per second.
g = acceleration constant of gravity in feet per second
h = head of air in feet causing the flow.









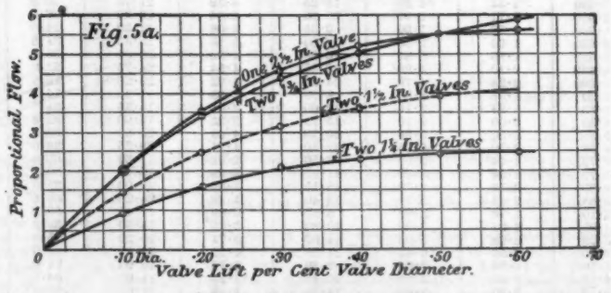


TABLE V.

Lift in inches	0·125	0·25	0·375	0·500	0·625	0·750
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Two valves, 1·75 in. ..	137	129	125	119	116	113
*Two valves, 1·50 in. ..	114	106	101	94	90	87
One valve, 2·5 in. ..	100	100	100	100	100	100
Two valves, 1·25 in. ..	85	77	72	65	59	54

* Interpolated.

Substituting the head in inches of water:

$$V = \sqrt{2gp\frac{62.31}{12w}} = \sqrt{2gpx\frac{5.193}{w}} = 18.275\sqrt{\frac{p}{w}}$$

where w is the weight of water in pounds per cubic foot, 62·31 is the weight of water in pounds per cubic foot, and p is the pressure head in inches of water.

This equation is deemed sufficiently accurate for the low pressures here subjected to examination.

Now, if A = the jet area, and
a = the valve area,

the mean velocity through the valve is $18.275\frac{A}{a}\sqrt{\frac{p}{w}}$

where p is the velocity pressure and w the density of the air at the jet.

The theoretical mean velocity through the valve is $18.275\sqrt{\frac{P}{W}}$, where P and W are, respectively, the pressure drop and the density of the air at the valve.

$$\text{The coefficient of efflux} = \frac{18.275\frac{A}{a}\sqrt{\frac{p}{w}}}{18.275\sqrt{\frac{P}{W}}} \text{ or } \frac{A}{a}\sqrt{\frac{p}{P}}$$

where the density of the air is the same in the jet and in the valve.

In computing the coefficient the valve area has been taken as π D h for all lifts. It is realised that for small lifts the aid of trigonometrical formulæ may be invoked to determine accurately the least area of opening, but the same formulæ are not applicable at higher lifts. Moreover, they are only justifiable upon the theory that the lines of flow are parallel to the slope of the valve seat, a condition which certainly does not obtain for any except the smallest lifts.

TABLE VI.

—	Relative Area.	Relative Flow at Lift equal to— 0·1 Diameter.	0·15 Diameter.	0·20 Diameter.	0·25 Diameter.
	p.c.	p.c.	p.c.	p.c.	p.c.
Two valves, 1·75 in. diameter	98	96	96	96	96
Two valves, 1·50 in. diameter*	72	70	69	69	69
One valve, 2·5 in. diameter	100	100	100	100	100
Two valves, 1·25 in. diameter	50	46	45	45	45

* By interpolation.

In Fig. 6 the coefficients of efflux will be found, plotted against valve lift in inches, and against lift in per cent. of diameter in Fig. 6a. These coefficients are considerably higher at low lifts, a feature somewhat difficult to explain satisfactorily. Both friction and dynamic losses should be greater at low lifts, as the ratio of perimeter to area is then greater and the angular deflection sharper. It seems probable that there is an approximation to a jet action at low lifts, the discharge taking place into a region of relatively low pressure, somewhat after the manner of the true jet used for measurement at the outlet end of the cylinder. The comparatively high discharge efficiency of any such jet seems to make this the most probable explanation of the high coefficients.

If such jet action takes place, the pressure in the valve area should approximate that of the cylinder itself, and the theoretical velocity through the valve should be computed upon the lower pressure rather than the higher. This would reduce the error involved in computing the theoretical flow and coefficient upon the assumption of atmospheric density in the valve, as has been done.

The maximum static pressure in the cylinder was 17·5 in. of water. As a pressure of 1 in. of water is equal to a pressure of 0·5768 oz. per square inch, this would equal a pressure of 10·09 oz., or 0·631 lb., per square inch, or an absolute pressure of 15·23 lb. per square inch, 755 mm. observed atmospheric pressure being equal to 14·60 lb. per square inch. The density of the air varying with the absolute pressure and the ratio of absolute pressures being 1·046, the error involved under the above assumptions would be about 2·2 per cent. as the density of the air enters the equation under the radical sign. This error would be materially less at the lower lifts, the pressures in the cylinder were then being considerably less. No appreciable error would appear to be introduced by assuming equal temperature and equal humidity at valve and jet for any given valve opening and pressure drop.

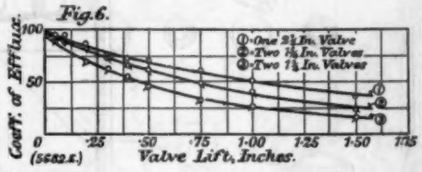
Referring again to Fig. 6, it will be noted that where the coefficients are compared at the same absolute lift, the differences between the three valve combinations are quite considerable, and that at the very low lifts the points plotted present some irregularities. The curves have been drawn to conform to the greatest number of points reasonably possible, and the curves in Fig. 6a have been plotted from those in Fig. 6. The points for the two larger combinations so nearly coincide in Fig. 6a that but one line has been drawn.

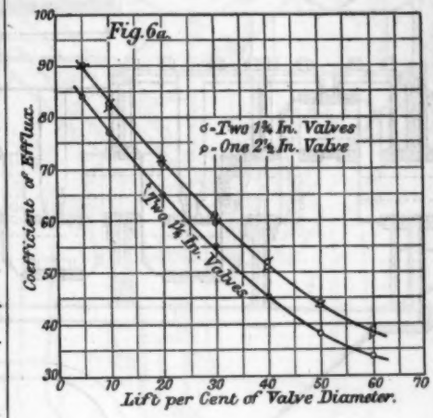
The relative intercepts of the coefficient curves in Fig. 6 at various absolute lifts, expressed in per cent. of the values for the single 2·5-in. valve, are presented in Table VII.

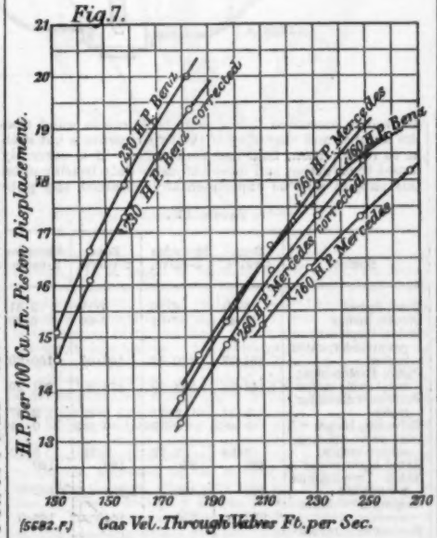
TABLE VII.

Valve lift in inches	Relative Coefficient of Efflux. 0·125	0·25	0·375	0·50	0·625
	p.c.	p.c.	p.c.	p.c.	p.c.
Two valves, 1·75 in. diameter	96	94	91	89	86
One valve, 2·5 in. diameter	100	100	100	100	100
Two valves, 1·25 in. diameter	87	79	73	69	64

In Fig. 6a it will be seen that when compared on a basis of equal valve lifts, expressed in per cent. of diameter,







the coefficients are much more nearly equal, the curves for the two larger combinations coinciding, and that for the small valves being but little lower. It seems entirely probable that even this small difference is largely caused by the converging lines of the passages leading to these small valves, as before explained. The comparative values are here shown.

General Considerations.—The only experimental investigation of the flow of air through poppet valves of which record was found in the technical publications was carried out as a thesis by Mr. R. M. Strong and Mr. F. W. Hollman, and later published by Professor C. E. Lucke under the title, "Pressure Drop Through Poppet Valves," vol. xxvii, Transactions of the American Society of Mechanical Engineers (1905). Professor Lucke seems to have been the first to call attention to two noteworthy characteristics, which are found to be supported by the data here presented; first, that the coefficient of efflux, computed for air at atmospheric density, is nearly constant for all pressure drops; and, second, that this coefficient is much larger for low lifts. Tests were made both with continuous flow, and intermittent flow, the latter being as nearly as possible similar to actual operating conditions for the two gas engines tested, and it was found that the coefficient of efflux for continuous flow was not the same as that for intermittent flow, even at the point of zero acceleration.

TABLE VIII.

Valve lift in per cent. of diameter	Relative Coefficient of Efflux. 0·10	0·15	0·20	0·25	0·30
	p.c.	p.c.	p.c.	p.c.	p.c.
Two valves, 1·75 in. diameter	100	100	100	100	100
One valve, 2·50 in. diameter	100	100	100	100	100
Two valves, 1·25 in. diameter	93	92	91	90	90

It is patent that extreme care should be exercised in any attempt to apply the results of continuous-flow experiments to flow under operating or intermittent conditions, since inertia and resonance effects in the inlet manifold will obviously make great differences in the absolute quantities, and these effects will vary with the type of manifold used. Moreover, the pressure drop, velocity, and coefficient will obviously vary with many other factors as between different engines, different speeds for the same engine, and as to instantaneous values at different points of the stroke for a given engine at a given speed.

However, in the question of design as to whether two inlet valves or one should be used, it is believed the comparative results here presented may be made to serve a real purpose. It is difficult to perceive any reason why the comparative relations obtaining between these three valve combinations for continuous flow should not find some parallel in the comparative relations between the same three combinations for intermittent flow, if no other variables are permitted to affect the comparative results in the latter case. Only inherent differences between the three combinations, effective with intermittent flow and non-effective with continuous flow, or *vice versa*, would appear capable of affecting this parallel, and it is improbable that such differences, if any, are of great magnitude.

It is hoped that these modest experiments will arouse interest in the question of multiple valves, and certainly the discussion of any direct comparisons obtained in practice would be very interesting. Aeronautic engines of to-day have so nearly approached the theoretical limit of efficiency that even small improvements may be well worth while, but it seems probable that the mechanical advantages of dual or multiple valves may be of even more importance.

The dimensions of the cylinder model used for these experiments offer a ready basis for discussion, and are commonly encountered in aviation engine practice, the bore being 5 in. and the diameter of combustion chamber 5·75 in. A combustion chamber of this size permits the use of two valves of 2·5 in. diameter, or four valves of 1·875 in. diameter, inclined at 15 deg. or 20 deg. to the cylinder axis in both cases. Four 1·75-in. valves can be placed in a 5·5-in. cylinder head inclined, or a 5·75-in. cylinder head vertical; and four 1·5-in. valves are even more readily accommodated in a 5-in. cylinder head, or a cylinder having the combustion chamber the same diameter as the cylinder proper. These valves may be placed vertically, and the cylinder is much more easily machined. The combustion chamber will have better proportions, and the slight increase in cylinder height will be more than offset as to overall height by the saving in spring length.

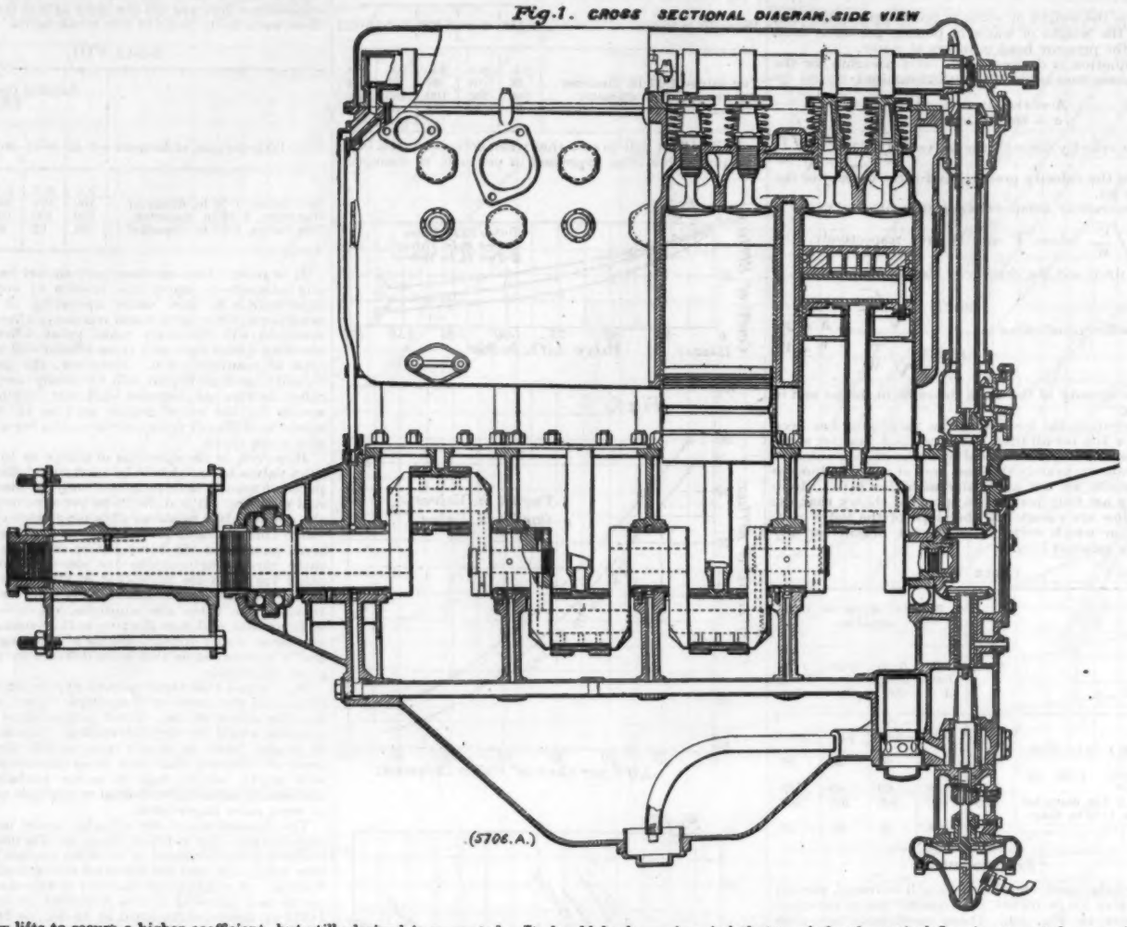
Two 1·5-in. valves will have a flow capacity equal to one 2·5-in. valve at the same pressure drop and the same lift, will present but 72 per cent. as much area to any pressure in the cylinder at the time of opening, and will weigh but 56 per cent. of the weight of the single valve, assuming that the weights vary as $D^{2.5}$, which is approximately correct for these sizes. Assuming any reasonable pressure in the cylinder at the time of valve opening, and spring tensions in proportion to valve weights, it is evident that the two small valves will require less than half the power to open them, and this will be a direct saving of mechanical loss, as valve action is not the type of reciprocating motion which can return during one portion of the stroke energy stored during another portion, excepting only the energy stored in the spring.

It has been said that valves in pairs are more difficult to cool than single valves, but this does not appear to stand analysis. The proportion of the 5-in. cylinder head occupied by the small valves is only about 95 per cent. of the proportion of the 5·75-in. head occupied by the large valve. The circumference of the two valves is 20 per cent. greater than that of the single valve, and although the seats would have somewhat less width, the distance of heat flow in this direction would be but 60 per cent. as great. As to the portion of the heat which flows to the guide, the conditions are also somewhat in favour of the small valves, the distance to the water-cooled portion of the guide being less and the proportion of water-cooled guide greater.

In one example of foreign engine design dual valves of about this size are lifted to one-half diameter, and give entirely satisfactory operation at speeds up to 2,200 r.p.m. The possibilities in this direction are largely untried, but the negative work used in overcoming valve resistance to inlet flow might be reduced with small valves at high lifts and the volumetric efficiency increased, without introducing serious mechanical difficulties. This, of course, is contrary to the principle

THE HISPANO-SUIZA AEROPLANE ENGINE.

Fig. 1. CROSS SECTIONAL DIAGRAM, SIDE VIEW



of using low lifts to secure a higher coefficient, but still the overall result might be beneficial.

The comparison of a single 2·5-in. valve to a pair of 1·75-in. valves may be analysed in much the same manner, and as to heat conditions the result would seem slightly in favour of the pair. If lifted 0·375 in., the capacity will be 25 per cent. greater than that of one 2·5-in. valve, according to the experimental results shown in Table V, or the resistance will be but 64 per cent. as great, the resistance varying approximately with the square of velocity or capacity. This should result in higher volumetric efficiency. The superficial area of the two combinations would be practically equal, but the weight of the pair would be but 82 per cent. of that of the single valve, with correspondingly reduced total spring tension and slightly reduced mechanical loss.

Interesting comparisons may be drawn from data published by *The Automobile Engineer*, London, vol. vii, Nos. 105–6–8–9 (1917) covering Benz and Mercedes engines, each make being constructed in both two-valve and four-valve models. Except for the valve changes and an increase in compression ratio from 4·50 to about 4·90, the design of the four-valve models is much the same as that of the respective two-valve types. The data represented in Table IX, the ratio of volume to horse-power and brake mean pressure being given for the rated power at 1,400 r.p.m. for each engine. The "valve factor" is one-half the product of inlet-valve opening area by the number of degrees open divided by the displacement of one piston, affording a ready index of relative valve capacity.

The valve factor for the four-valve Mercedes is but slightly larger than that of the two-valve, and the mean effective pressure is increased only 5 per cent., which is practically accounted for by the increase in compression ratio from 4·50 to 4·94. In the Benz four-valve, the factor is increased 35 per cent. and the mean effective pressure increased 10 per cent., only about one-half of which can be due to the increase in compression ratio from 4·50 to 4·91.

In Fig. 7 a comparison is made of the power output of these four engines plotted against gas velocity through the inlet valve. These velocities are computed for this comparative purpose, as the ratio of piston displacement per explosion to one-half the product of valve-opening area by the time of the opening. The broken curves represent the four-valve Benz and Mercedes, respectively, reduced approximately to compensate for difference in compression ratio.

In conclusion, a summary of the results experimentally derived is presented. It should be borne in mind that the number and character of the experiments is not such as to render them final and conclusive. It is earnestly hoped that further and more extensive data bearing upon this subject will be experimentally obtained and published, and it is believed that the results here presented will be found substantially correct in the light of later research. Caution should be exercised in the application of these results, for apparent similarity with respect to air flow is often most deceptive.

TABLE IX.

Engine.	Benz. 4-valve.	Mercedes 4-valve.	Benz 2-valve.	Mercedes 2-valve.
Bore, inches ..	5·71	6·30	5·12	5·51
Stroke, inches	7·48	7·09	7·09	6·30
Piston displacement per cylinder, cubic inches	191·38	220·82	146·05	150·20
Piston displacement, total cubic inches	1,148·30	1,324·90	876·30	901·20
Valve port diameter, inches ..	2·04	2·17	2·42	2·67
Valve lift, inches ..	0·465	0·398	0·433	0·440
Inlet valve opening, square inches ..	2·99	2·72	3·29	3·70
Rated horse-power ..	230	260	160	160
Rated revolutions per minute ..	1,400	1,400	1,400	1,400
Maximum horse-power	250	270	164	162·5
Maximum revolutions per minute..	1,650	1,650	1,400	1,400
Inlet-valve opening, degrees	245	228·3	240	213
Area inlet pipe, square inches ..	3·65	6·35	2·96	3·54
Cubic inches piston displacement per horse-power ..	4·99	5·10	5·48	5·63
Compression ratio ..	4·91	4·94	4·50	4·50
Valve factor.. ..	3·80	2·82	2·70	2·62
Brake, mean effective pressure ..	113·0	107·5	103·0	102·0

CONCLUSIONS.

1. The coefficient of efflux is practically constant, for all pressure drops (at least below 1 lb. per square inch) where the lower pressure is approximately atmospheric, and the theoretical flow is computed upon air at atmospheric density.

2. Under conditions of general similarity, the coefficient of efflux is very nearly the same for valves of different sizes, at equal lifts expressed in per cent. of their respective diameters.

3. Lifting a valve one-quarter of its diameter may develop an area of opening geometrically equal to its port area, but affords a capacity less than 67 per cent. of that of the unobstructed port, at the same pressure drop; a lift equal to one-half diameter develops 80 per cent. to 90 per cent. of this maximum capacity.

4. At the same pressure drop, one valve of diameter D and lift h is equal in capacity to:

First. A pair of valves of diameter 0·707 D (equal port area) and lift 0·707 h.

Second. A pair of valves of diameter 0·6 D and lift h, for values of h not exceeding about 0·25 D.

THE HISPANO-SUIZA AEROPLANE ENGINE.

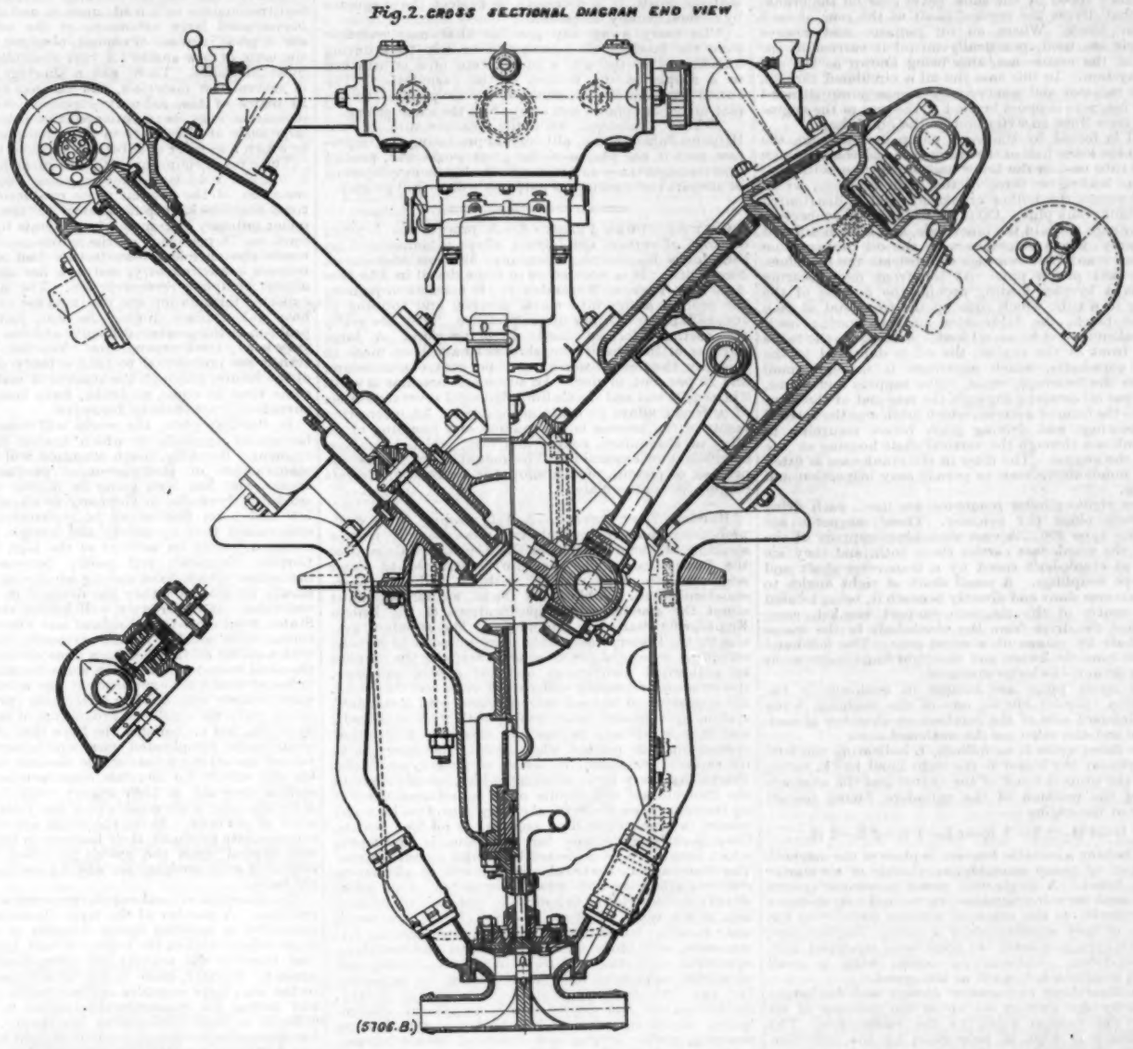
WE reproduce on the present and opposite pages, from our New York contemporary *Aviation*, drawings of the Hispano-Suiza aeroplane engine, a type of motor which has been very extensively adopted in France, where seventeen factories are stated to have been recently turning out 120 of these engines per day. The engines are manufactured under the Birkigt patents, these being owned by the inventor, Mr. Marc Birkigt, and the parent company, Automoviles Hispano-Suiza, which has a factory at Barcelona, Spain. In the United States the manufacturing rights were taken up by the Wright-Martin Aircraft Corporation, of New Brunswick, N.J., and the account in our contemporary deals particularly with the types constructed by this Corporation and the sub-contractors associated with them. The description given is as follows:—

"Four models of Hispano-Suiza engine have been produced in the United States. These are designated Models A, I, E and H. Model A has a bore of 120 mm. (4·72 in.) and a stroke of 130 mm. (5·11 in.), and develops 150 h.p. at 1450 r.p.m. at sea level. Although formerly used for combat and pursuit work, this engine has now been relegated to use in training planes. Model I, also of 150 h.p., is the same as Model A, except that it has the new straddle-fork type of connecting rod, the magneto drive and the timing are different, and there are some slight modifications in the piston mounting.

"While Model E has the same bore and stroke as

THE HISPANO-SUIZA AEROPLANE ENGINE.

Fig. 2. CROSS SECTIONAL DIAGRAM END VIEW



Models A and I, it develops 180 h.p., the compression ratio having been raised from 4·72 to 1 in the Model I to 5·33 to 1 by increasing the distance from the centre of the piston pin holes to the top of the piston. A larger Stromberg carburettor with 2-in. barrels is used instead of the smaller one fitted to the Model I. This is necessary to take care of the increased volume of mixture required by the higher-engine speed of the Model E, this being 300 r.p.m. greater than in the Model I. The Model E has been widely employed fitted to British SE-5 planes, which are designed for combat and general purpose work.

"The three models mentioned above resemble the original French design very closely in their essential features, although incorporating a number of variations in dimensions and details of design. The 300 h.p. type, Model H, may be characterised as entirely American except for its basic principles. The Wright-Martin experimental department at New Brunswick has completed about twenty of these engines, and they are stated to have proved unusually powerful and speedy. The bore of the Model H is 140 mm. (5·511 in.) and the stroke is 150 mm. (5·905 in.). Two other important features which are different in the Model H as compared with the other three engines are the carburettor and oiling system. Like the others, however, this model is designed for fighting, pursuit and similar activities.

"The Model I Hispano-Suiza may be described as typical of the entire series, with the exception of the points of difference outlined above. It is a fixed-cylinder, water-cooled engine, with eight cylinders arranged in two blocks of four, which are set at an angle of 90 deg. The aluminium crank-case is divided at the centre line of the crank-shaft, the faces of the two halves being ground to a perfect fit, as no gasket is used between them. They are fastened together by bolts. The lower half of the crank-case is unusually deep, forming a large oil reservoir and also stiffening the engine. The upper half carries the two-cylinder blocks, flanges at the base of the cylinders being attached by means of bolts.

"A four-throw crank-shaft is used, 180 deg. between throws. It is made of chrome nickel steel, machined all over, and is hollow for lightness. Four plain main bearings, bronze backed and lined with babbitt, and one annular ball main bearing at the rear (magneto end) of the engine carry the shaft, which is supported between the crank-case halves. A double-row, ball-thrust bearing located in the front of the crank-case takes the thrust of either a tractor or pusher propeller. The crank-shaft is provided with a taper at the front end, having a key for the propeller hub.

"The cylinder blocks are of cast aluminium and incorporate water-jackets surrounding the heads of the forged steel cylinders, which are made in the form of sleeves, threaded on the outside to screw into corresponding threads, which are quickly and easily cut in the cylinder blocks by means of large compressed air taps. Each cylinder is flanged at the bottom and closed at the top, the upper surface being flat and carrying the two valve seats. The cylinder blocks also embody the intake and exhaust passages and the valve ports.

"The connecting-rods are of heat-treated steel and tubular in construction. The new straddle-fork type of rod, which is of American design, is forked at the bottom and bolted to a two-piece bronze box lined with babbitt, two bolts being used at each side. The bronze box bears directly on the crank-shaft, and the other connecting-rod bears on the outer and central portion of the bronze box, the shaft itself working between the forked ends of the straddle rod. Bronze bushings are provided at the upper ends of each pair of connecting-rods.

"Pistons are of cast aluminium, ¼ in. thick at the head, the sides tapering from ⅜ in. at the top to ¼ in. thickness at the bottom, this taper construction facilitating the dispersion of the heat of combustion. There are four narrow rings in two grooves at the top of each piston, and near the bottom there is one oil ring with relief just below it. Case-hardened alloy steel is used for the piston pins, which are of large diameter and hollow in construction. These pins float in both sides of the piston, as well as in the upper end of the connecting-rods, a piston pin-lock ring holding each pin in place.

"The overhead camshaft which operates the valves in each cylinder block is hollow and carried in three plain bronze bearings, each shaft being driven by two pairs of bevel gears and a vertical shaft connection to the crank-shaft at the rear of the engine. These vertical shafts are protected by light steel tubing, and each is made with a screw-driver, or Oldham coupling, type of joint slightly below the middle to permit removing the cylinder blocks without dismantling other parts. One of the camshafts, that in the left-hand block, besides operating the valves, drives the piston of a small air pump mounted on the valve-gear housing. This pump is used for maintaining pressure in the gasoline tank where the pressure feed fuel system is used. The oil-tight cast aluminium housings which inclose the camshafts and valve mechanism are easily removable.

"Valves are of tungsten steel with large diameter hollow stems, working in bushings of cast iron. They are set vertically in the cylinders along the centre of each block, and the overhead camshafts operate them directly by making contact with case-hardened, flat-headed adjusting disks at the upper ends of the stems, rendering rocker arms unnecessary. Each valve is held to its seat by two concentric helical springs, either one of sufficient strength to ensure proper seating if the other breaks. A further advantage of this construction is that it effects more rapid and more positive opening and closing of the valves. Clearance between the cam contour and the adjusting disks may be easily corrected when necessary by means of serrated washers pressed upward by the springs which hold the adjusting discs in place, permitting easy turning with a special wrench, which displaces the adjusting discs angularly in the valve stems. The whole assembly can slide freely lengthwise, although the spring retainer washer is held in place angularly by tenons engaging slots in the stem.

"A positive pressure system is used for lubrication,

the oil being forced to the bearings, &c., by a sliding vane eccentric pump mounted vertically in the lower half of the crank-case immediately under the rear end of the crankshaft. This pump is driven at 1·2 times crankshaft speed by the same bevel gear on the crankshaft that drives the vertical shaft at the rear of each cylinder block. Where an oil radiator and reserve reservoir are used, practically no oil is carried in the sump of the crank-case, this being known as the dry sump system. In this case the oil is circulated through the oil radiator and reservoir by a gear pump situated on the magneto support bracket at the rear of the engine and driven from an extension of the crankshaft.

"Oil is forced by the vane pump first through the filter in the lower half of the crank-case and then through a steel tube cast in the lower half of the case, with connections leading to three of the main bearings, where the oil enters the hollow crankshaft and is distributed to the four crank pins. Oil is fed to the outer connecting rods through holes in the inner rods, and is then diffused as a spray, which combines with the oil thrown from the main crankshaft bearings to lubricate the cylinders, pistons and piston pins. At the front main bearing there is a by-pass leading around the outside of the bearing to a tube which runs up the front end of each cylinder block, the lubrication of the bearing itself being taken care of by an oil lead. Passing up the tubes at the front of the engine, the oil is delivered to the hollow camshafts, which distribute it through small holes to the bearings, cams, valve tappets and stems, the excess oil escaping through the rear end of the camshafts in the form of a stream which lubricates the vertical shaft bearings and driving gears before returning to the crank-case through the vertical shaft housing at the rear of the engine. The filter in the crank-case is fitted with a removable screen to permit easy inspection and cleaning.

"Two eight-cylinder magnetos are used, each firing two spark plugs per cylinder. These magnetos are the Dixie type 800. A cast aluminium support at the rear of the crank-case carries them both, and they are driven at crankshaft speed by a transverse shaft and gear type couplings. A small shaft at right angles to the transverse shaft and directly beneath it, being located in the centre of the magneto support bracket, communicates the drive from the crankshaft to the transverse shaft by means of a spiral gear. The left-hand magneto runs clockwise, and the right-hand instrument turns in an anti-clockwise direction.

"The spark plugs are located in bushings in the aluminium cylinder blocks, one of the bushings being on the inboard side of the combustion chamber of each cylinder and the other on the outboard side.

"The firing order is as follows, L indicating the left-hand cylinder block and R the right-hand block, facing toward the propeller end of the engine and the numbers denoting the position of the cylinders, facing toward the rear of the engine :—

1 L—4 R—2 L—3 R—4 L—1 R—3 L—2 R

"By bolting a suitable bracket in place of the magneto support in oil pump assembly, an electric or air starter may be fitted. A single-unit motor generator system may be used for a combination starter and long-distance wireless outfit, as the magneto wireless connection has a radius of only approximately 5 miles. Engines used in pusher type seaplanes are sometimes equipped with a geared-down, hand-starting crank, with a small magneto to give a hot spark at low speed.

"The Stromberg carburettor meters and discharges the fuel by the suction set up in the delivery of air through the venturi tubes to the carburettor. The fuel delivery is kept in proportion by the induction of air into the jet, thus maintaining a constant mixture throughout the throttle range.

"When arranged for gravity feed, the gasoline tank is placed so that it will give 1 lb. to 2 lb. head at the carburettor for any position of the machine when in flight. Where pressure feed is used, the pressure is maintained by the pump located on the valve-gear housing of the left-hand cylinder block, a relief valve being placed in the line to prevent the pressure at the carburettor becoming greater than 2 lb. This valve is designed so that it can be adjusted in accordance with the varying altitudes at which the machine travels. Sufficient pressure for starting is obtained by using a hand pump when this system of fuel feed is employed. If desired, a vacuum tank system may be used, the vacuum being usually secured by taking a lead from the throat of a compound venturi, placed in the draft of the propeller, to the main gasoline tank, a check valve being placed in the line and a branch line leading to the auxiliary fuel tank.

"The engine cooling water is circulated by a centrifugal pump with two discharge outlets which is mounted directly underneath the oil pump. The water pump is driven from the same shaft as the oil pump at 1·2 times engine speed. Its capacity is 100 litres (26·50 gallons) per minute at an engine speed of 1450 r.p.m. The cylinder water-jackets have a capacity of 18½ litres (4·9 gallons) or, by weight, 18½ kg. (41 lb.).

"An interrupter driving mechanism is used to fire a machine gun which is synchronised with the propeller. This mechanism is operated by a gear pinned to the lower gear on the lower half of the vertical shaft, which drives the camshaft of either the left or right-hand cylinder block. Two ball bearings carry the interrupter shaft, which is driven at crankshaft speed. It is bolted by double flange connection to the driving shaft, one flange having one less bolt hole than the other. When the firing mechanism is properly set, a bullet fired from the gun will miss the trailing edge of the propeller by ¼ in.

"In mounting the Hispano-Suiza engine in a plane, it is anchored on a rigid support, lined at the points of contact with fibre or sheet metal, the engine base being set flat on the support members. To facilitate disassembly, the camshaft and valve-gear housings are usually left exposed, enabling the plane constructor to use smaller cowls. When an engine is mounted without cowls, it is necessary to protect the magnetos by covers, usually of leather.

"To carry away any gasoline that may overflow from the bowl of the carburettor or drip back during manœuvres in the air, a small drain pipe is attached to a nipple at the bottom of the carburettor. The excess gasoline is discharged as far as possible to the rear under the planes and away from the exhaust line.

"Those connected with the manufacture of the Hispano-Suiza engine, although appreciating the important part it has played in the great world war, predict that its importance as a factor in the future development of aircraft for commercial purposes will be still greater.

CASTING UNDER PRESSURE.—A process for forming castings of certain non-ferrous alloys is announced by the Morris Engineering Company, 39, Cortlandt-street, New York. It is referred to in some detail in *The Iron Age*, New York, of November 7. It consists in pouring the molten alloys into metal moulds, and forming or congealing the castings under pressure. They are really die castings formed under high pressure. A large number of fuse bodies for shrapnel have been made in this way, the composition being 80 per cent. of aluminium, and 20 per cent. of zinc. An automatic machine is used. The tensile test and elastic limit figures of several castings of different alloys so made are quoted. An interesting result of the process is the making and handling of an alloy of aluminium, copper and iron, which has a low co-efficient of expansion. The manufacture, under the process, of pistons, of this alloy, for high-power aircraft engines is contemplated.

BRITISH EAST AFRICA.—A Bill dealing in a comprehensive manner with electric power supply is now awaiting its final reading in the Legislative Council of the Protectorate. The measure is designed to foster and promote bulk supply methods and to ensure standardisation. Public and local authorities must adopt the standards and specifications of the British Engineering Standards Committee. The standard system for the Protectorate will be three-phase at 50 periods, excepting for special purposes, and, excepting the supplies to authorised distributors and for special purposes, the pressures of supply will be 415 volts and 240 volts. All apparatus to be used in connection with a standard system by a licensee must comply with these standards, and that which may be used by others on a standard system must be marked when usual or necessary as to its capacity or value, in terms of British standards. Practically every form of energy which industrialists in the Protectorate will require must be obtained from or by the conversion of electrical energy generated by water power, internal-combustion engines, or oil-fired boilers. Consequently a demand for apparatus is developing which should not be neglected by British manufacturers. The Government electrical engineer will be pleased to receive catalogues and other information, with prices where possible, relating to hydraulic, internal-combustion and steam types of prime movers, electric generators and motors, transformers, E.H.P. transmission line materials, split-phase and other control and switching apparatus, indicating and recording meters, testing and measuring apparatus, &c. Also relating to apparatus for any industrial application of electrical energy, including farm and electro-culture equipment, electrolysers, ozonisers, automobiles, batteries and battery charging, coffee drying and roasting, steam raising, mashing and distilling, casting and welding, cement burning, domestic heating and cooking, and X-ray and electro-medical equipment, &c., &c. Inquiries from those interested are solicited and should be addressed to the Government Electrical Engineer, Nairobi, British East Africa.

MESSRS. BOLLING AND LOWE'S TRADE REVIEW.—In their annual report, recently issued, Messrs. Bolling and Lowe state that trade during the past year has been of necessity restricted, and in many cases interfered with, consequently little ordinary business has been possible. It is the hope of all, that Government restrictions which have served their purpose and are no longer necessary, will be withdrawn at the earliest possible moment, thus leaving the manufacturer and merchant a free hand to transact their business in their own way. The chief interests of this old-established firm lie in the merchant branch and they have no hesitation in repeating what has often been said before, namely, that the prosperity of this country has been largely due to the initiative and energy of the merchant in securing business from overseas, often only after much labour, considerable expense in travelling, advertising, &c., and last, but not least, to the merchant's varied experience and his willingness to agree to buyers' terms and conditions, which are not acceptable to most manufacturers. In many directions, they add, it would seem that the iron and steel trade in this country is fully equal to maintaining and extending its pre-war connections, and the fact that an exchange is being formed in the City of London where buyers and sellers can meet to do business, is another proof of progression. As regards prices of iron and steel and metals, during the last year these have as a rule been fixed by Government Departments, and there is consequently nothing to be said about them. However, they think that the fixing of maximum prices should be continued for some short time to come, provided the manufacturer is allowed a fair profit on his output; as regards the merchant, the severe competition to which he has already become accustomed will keep him sufficiently controlled.

THE GERMAN CHEMICAL INDUSTRY AFTER THE WAR.

DURING the war the German chemical industry has had tremendous calls made upon it, and these have often necessitated large extensions of the works and plant and a great increase of capital, obtained partly through the issue of new shares for vast amounts and partly by State subsidies. There was a shortage to begin with of several raw materials, and the blockade put a stop to many of the ordinary supplies. Among the new industries may be mentioned the manufacture on a large scale of nitrates from the atmosphere, in addition to which a number of substitutes had to be evolved.

These novel claims upon the chemical industry entailed a marked reduction, and in some cases a complete cessation, of the regular peace production, at the same time the blockade put a stop to the export, which under ordinary circumstances accounts for about 70 per cent. to 75 per cent. of the entire production. As a result the chemical manufacture had almost entirely become a war industry, and now has again to face an almost complete reconstruction. The sudden and unexpected termination and the immense extensions which have taken place during the war, have produced a problem of the greatest difficulty and one likely to entail very heavy fresh expenditure. Yet the industries concerned are understood to take a fairly optimistic view of the future, although the chances of making profits for some time to come, no doubt, have been substantially curtailed, if not entirely destroyed.

In the first place, the works will resume the manufacture of dyestuffs in which branch they were pre-eminent. Secondly, much attention will be paid to the manufacture of pharmaceutical products, which, of course, also has been going on during the war. The stocks of dyestuffs, in Germany as elsewhere, are very low and must first of all be replenished. Hopes are entertained that by-and-by the foreign trade may be resumed, partly on account of the high quality of the German chemicals and partly because the foreign industries which have sprung up during the war will hardly be able to satisfy the demand in the respective countries. It is perfectly well known that the United States, even more than England and France, have made considerable strides in the dyestuffs industry. Notwithstanding all that has been done abroad, the German chemical industry relies with some confidence upon the value of that vast experience it has accumulated. It quite realises that a fairly formidable competition may spring up in the wholesale production of the more simple dyestuffs, but it cherishes the hope that this will hardly occur in the complicated ones, which have always been one of the strong points of the German manufacturers. On the whole the German manufacturers look for a serious decrease in their export trade for some time after the war, a decrease which has been estimated at some 40 per cent. As for the works which manufacture intermediate products, their business in these specialities will depend upon the extent to which the factories requiring such products are able to resume work on the old basis.

The question of coal supply presents a very difficult problem. A number of the large chemical works have succeeded in securing lignite deposits so as to become more independent in the matter of fuel, but even in that case there is the scarcity of rolling-stock to contend against. Further, there is the labour question; owing to the war, large numbers of fresh hands were engaged, and during the reconstruction period it will be very difficult to find employment for them. Under these circumstances the introduction of an eight-hours' working day will not cause any particular trouble.

The arrangements made during the war with the Explosives Group, as to a regulation of the respective fields of work and the competition between them in times of peace, will no doubt prove very useful. The chemical industry will discontinue the manufacture of explosives, and on the other hand the explosives concerns will no longer produce intermediate chemical commodities. No solution of the problem of how the chemical industries shall utilise the vast extensions, added during the war for military purposes, has as yet been arrived at. In the meantime, many of these new installations have already been closed up. These extensions, which have swallowed up large portions of the profits made during the war are thus likely to remain entirely unproductive for at least some time to come, and it will admittedly be difficult to put their value as assets in future balance-sheets. Still the reserves of the concerns in question have been materially swelled during the war.

Although the prospects of the German chemical industry, from a general point of view, appear anything but bright at present, there are not, as already mentioned, any signs of pronounced pessimism within the industry itself; on the contrary, a fairly cheerful view is said to exist.

AVIATION IN JAPAN.—Millionaires in Japan are now bent on promoting the progress of aviation, says *The London and China Telegraph*. The Kawasaki Shipbuilding Company has recently despatched Naval Lieutenant Himasu to France, who, upon his return home will establish a factory for flying motors near Kobé. Over 20 operatives sent by the Mitsubishi firm to France and Italy will return home in a month or so. Dr. Ito has been designing the establishment of an extensive aviation factory for the firm, and has already bought a foreign patent for flying motors. The Kawasaki Works will chiefly serve the Navy, and the Mitsubishi the Army. The Mitsui firm will establish an aviation department, and will shortly send Mr. Tsunetaro Oguri, a civil aviator, to America, further to study the latest military aeroplanes.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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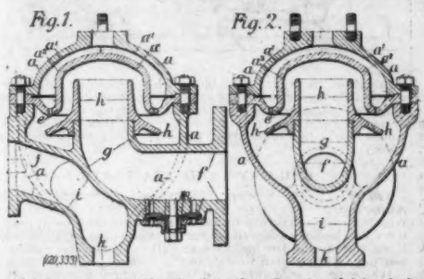
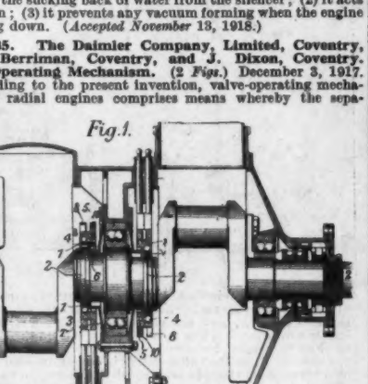
GAS ENGINES, PRODUCERS, HOLDERS, &c.

120,333. A. G. Langdon, Northam, Southampton. Water-Cooled Exhaust Silencers. (9 *Figs.*) March 21, 1918.—This invention relates to water-cooled exhaust silencers for internal-combustion engines in which the exhaust gases are cooled and condensed by contact with a water-cooled surface. An exhaust silencer, according to this invention, consists of a spherical body *a*, the upper portion of which comprises a cooling dome a^1, a^2, having a water inlet *d*, the lower portion being perforated at *e*; an exhaust inlet *f* with an internal passage *g*, which passage extends into the upper portion of the cooling dome a^1, a^2, and is provided with a deflector A; this deflector conducts the exhaust gases into the body of the spherical vessel,

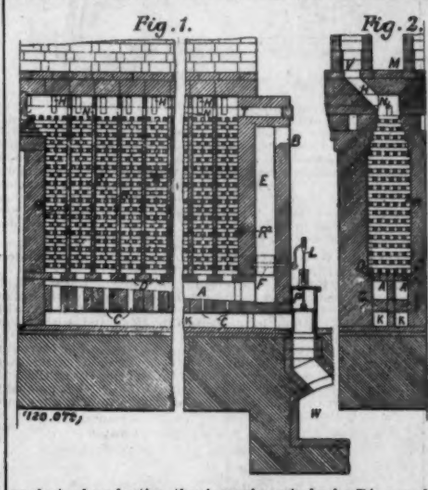


which has a passage *i* leading into the exhaust outlet *j* and also a passage *k* forming the water outlet from the vessel. The exhaust inlet *f* is provided with a disc relief valve *m*. This valve is provided with escape holes, and is placed in a recess formed in the inlet exhaust branch of the silencer, and is held in position by a cover and bolt and spring. The exhaust branch recess is provided with holes and the cover is provided with corresponding holes, the holes in the valve being nearer the centre of the valve than the holes in the recess and cover. This relief valve provides three essential features: (1) In case the engine backfires it prevents the sucking back of water from the silencer; (2) it acts as a drain; (3) it prevents any vacuum forming when the engine is cooling down. (*Accepted November* 13, 1918.)

120,285. The Daimler Company, Limited, Coventry, A. E. Berriman, Coventry, and J. Dixon, Coventry. Valve-Operating Mechanism. (2 *Figs.*) December 3, 1917.—According to the present invention, valve-operating mechanism of radial engines comprises means whereby the separate inlet tappets arranged in one plane at right angles to the crankshaft and exhaust valve tappets arranged in another and parallel plane, are independently controlled from a single eccentric. An eccentric 1 is mounted upon the crankshaft 2; a ring 3 is supported upon the eccentric 1 through the medium of antifriction balls 4. The ring 3 extends in the direction of the axis of the crankshaft beyond the eccentric 1, and such overhanging portion is formed internally with gear teeth 5, which engage teeth 6 formed on a stationary member 7 fixed to the crank-case of the engine. The ring 3 is formed with two sets of cam surfaces arranged in parallel planes; one set 8 operates the exhaust valves of one bank of radial cylinders and the other set 10 operates the inlet valves of the same bank of radial cylinders. The gear teeth 5 of the cam ring 3 being eccentric to the teeth 6 of the stationary member 7 and engaging therewith at one part, produce a controlled rotary motion of the cam ring 3 when the crankshaft 2 revolves, and the motion of the cam ring 3 and the shape of its cam surfaces is therefore such that the exhaust and inlet valves of each cylinder are separately operated in their correct sequence. (*Accepted November* 13, 1918.)

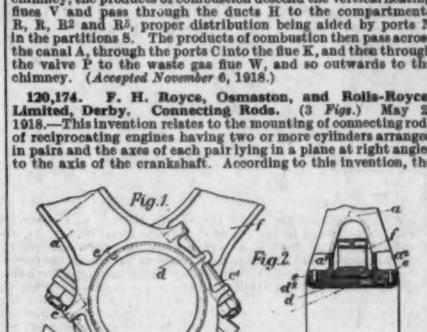


120,079. D. Bagley, Westminster, London. Regenerators. (2 *Figs.*) October 22, 1917.—In coke ovens having beneath each oven a regenerator which serves the heating flues of the oven and is subdivided into compartments by vertical partitions, an air supply flue is provided beneath the regenerator the cross section of which flue decreases uniformly from the end at which the air is admitted to the other end. The regenerator is subdivided into 14 compartments extending beneath one-half of a regenerative oven equipped with 30 vertical heating flues, the remaining section of the group (not shown) likewise comprising 14 precisely similar compartments extending beneath the remainder of the oven. B is the air intake inlet, E the air intake flue. A represents the tapered air supply canal which is common to the whole regenerator and communicates with the compartments by the ports D. T is the inspection port. H, H, are the ducts conducting the preheated air to the vertical heating flues V, one being shown in Fig. 2. F represents the air supply control valve and P the valve for controlling the waste gas flue W. The coking chamber is represented by M. L is the common actuating lever for the air supply control valve F and the valve P. Assuming the checker bricks within the regenerator to have been heated to the desired degree by the descending



products of combustion, the air supply control valve F is opened, and the valve P closed. Simultaneously the draught is arranged to draw air through the air intake inlet B and the air intake flue E into the canal A, which consists of a tapered channel designed to give uniformity to the velocity of the incoming air beneath each port D, thus ensuring uniform velocities of the air currents in the several compartments. The air rises within the compartments, is gradually heated by transmission of the heat stored in the checker bricks, and passes through the ducts H placed beneath each of the 15 vertical heating flues V, where it meets the heating gas and combustion is effected, the products of combustion ascending these heating flues. Upon reversal of the draught by closing the air supply control valve F and opening the valve P, thus placing the products of combustion canal K in communication with the waste gas flue W and the chimney, the products of combustion descend the vertical heating flues V and pass through the ducts H to the compartments R, R, R^2 and R^5, proper distribution being aided by ports N in the partitions S. The products of combustion then pass across the canal A, through the ports C into the flue K, and then through the valve P to the waste gas flue W, and so outwards to the chimney. (*Accepted November* 6, 1918.)

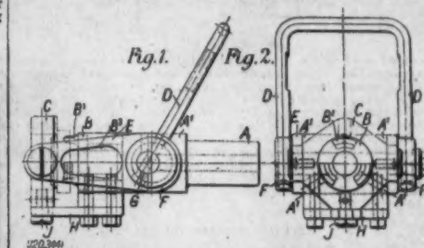
120,174. F. H. Royce, Osmaston, and Rolls-Royce, Limited, Derby. Connecting Rods. (3 *Figs.*) May 2, 1918.—This invention relates to the mounting of connecting rods of reciprocating engines having two or more cylinders arranged in pairs and the axes of each pair lying in a plane at right angles to the axis of the crankshaft. According to this invention, the



connecting rods are constructed, the one with a forked end and the other with a single end to be located within the forks of the forked end, and there is provided a bush taking its bearing on the crank-pin, extended from end to end of the crank-pin, and having, at the end parts which are to receive the forks, annular grooves or recesses and, inside the eyes of the forks, corresponding annular projections are provided to engage the said grooves or recesses. *d* is the forked rod provided with two forks d^1 and d^2, *d* is the bush made in halves and lined with white metal; d^3 are grooves formed on the outside of this bush which engage with corresponding projections inside the eye of the forks d^1 and d^2. The grooves and projections are so proportioned that when bolts *e* and e^1 are tightened up, the projections of the eyes are pressed closely into the grooves upon the bush. Dowel pins *e* are provided to ensure that the joint between the two halves of bush *d* falls approximately in the same plane as that between rod and cap of the forked rod and to ensure that the bush shall not rotate relatively to the eyes of the forked ends. These dowel pins are driven tightly into the part of the eye integral with the rod and the caps fitting into holes provided for their reception in the bush. *f* is the connecting rod with a single eye which encircles and takes its bearing upon a smooth parallel portion of the bush *d* between the grooved ends. (*Accepted November* 6, 1918.)

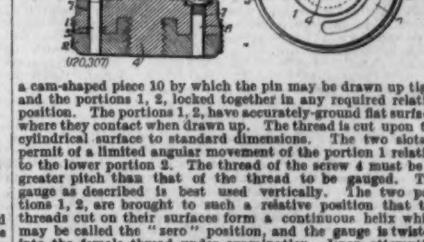
MACHINE AND OTHER TOOLS, SHAFTING, &c.

120,344. William Beardmore and Co., Limited, Parkhead, Glasgow, and T. Broadbent, Parkhead, Glasgow. A Work-holder. May 1, 1918.—The invention provides a simple and effective holder for accurately locating and holding work during turning, boring and like operations. A device made according to the invention comprises essentially a base member adapted to be secured in the turret or other machine part and bearing a locating face at right angles to its axis, a clamping piece hinged upon the base member and adapted to hold the work against the locating face, and it may centre it thereon, and locking means applied between the base member and the clamp and adapted to hold the work rigidly in place. The base member consists of a shank A adapted to be secured in a lathe turret and having an entablature A^1 against the inner face of a recess in the face of which is located a work receiving part B, having upstanding annular figures B^1, adapted to locate the work and a sleeve part B^5 serving as a guide and steady for the boring tool. A clamping piece C having a central aperture engaging



the forward edge of the work is pivoted on links E, apertures in the rear ends of which are engaged by eccentrics F, mounted on a spindle G passing through the base member. These eccentrics are pinned upon their spindle by the ends of a bail D. One eccentric is rigidly secured to the spindle, but the other eccentric is allowed a certain small angular movement on its spindle for a purpose hereinafter explained. In order to remove the work, the bail D is thrown forward, so, by the action of the eccentrics F, releasing the clamping piece C, which may then be swung upwards. The work is then removed and a new piece located upon the fingers B^1, the clamping piece C is then replaced so that its locating stud J enters the slot in the bracket-piece H, and the bail D is swung back, thus clamping the piece firmly in place through the action of the eccentrics F, the pressure of this clamping action being equalised over the work by reason, firstly, of the pivotal action of the clamping piece on its pins, and, secondly, by the amount of play which is allowed by that eccentric F which is slightly loose. (*Accepted November* 13, 1918.)

120,307. T. Browett, Hampstead, London. Gauging Screw Threads. (7 *Figs.*) January 10, 1918.—According to the present invention, a gauge for screw threads comprises the combination with two threaded parts, each having a portion or portions of a standard thread and arranged on a common axis, so that when the two parts are together or are separated by a predetermined amount, the thread portions form part of a continuous thread, of means for separating the two parts, as, for example, a threaded portion on one part with which a threaded portion of the other part engages, or a threaded central rod with which a threaded portion of one of the parts engages, the said thread being of different pitch from that of the standard thread. The gauge shown is suitable for determining the characteristics of an internal thread formed to receive a plug provided with a male thread. The gauge has two threaded parts, an upper 1 and a lower 2, each of which carries two or three threads so that the gauging pieces are of the nature of discs. The portion 1 is provided with the usual milled handle 3. The portion 2 is attached to the upper by a central screwed plug 4. The portion 2 is further provided with two or more parallel axial pins 5, 6, ground to be an accurate sliding fit in circular slots 7 formed in the portion 1. These pins project beyond the upper surface of the portion 1 and one of them, 5, is formed as a pointer 8 which moves along a scale marked along one of the slots 7; the other, 6, has pivoted to it

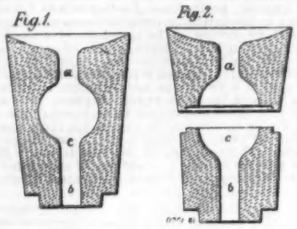


a cam-shaped piece 10 by which the pin may be drawn up tight and the portions 1, 2, locked together in any required relative position. The portions 1, 2, have accurately-ground flat surfaces where they contact when drawn up. The thread is cut upon the cylindrical surface to standard dimensions. The two slots 7 permit of a limited angular movement of the portion 1 relative to the lower portion 2. The thread of the screw 4 must be of greater pitch than that of the thread to be gauged. The gauge as described is best used vertically. The two portions 1, 2, are brought to such a relative position that the threads cut on their surfaces form a continuous helix which may be called the "zero" position, and the gauge is twisted into the female thread under examination. Upon attempting to unscrew the gauge, however, the portion 1 will, if not tightly clamped to the bottom portion 2 rotate in an anti-clockwise direction, in the case of the right-hand thread, and the portion 1, will be separated from the lower by an amount determined by the pitch of the central thread. This action will take place until the portion 1 of the gauge travels so far relatively to the lower as to eliminate any "play" or "back-lash" between the thread

under examination, and will lock itself in this position, so that the gauge cannot be removed. The extent of the angular motion required to effect this locking determines the accuracy, or otherwise, of the thread, and by the pointer 8, the exact extent of this angular movement can be gauged and read on the circular divided scale. (*Accepted November* 13, 1918.)

MINING, METALLURGY AND METAL WORKING.

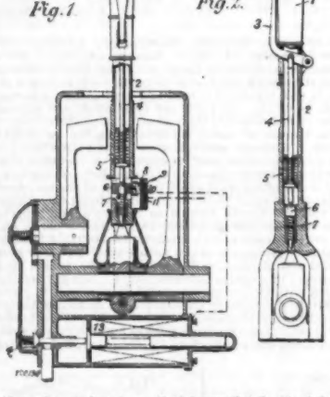
120,116. John Brown and Co., Limited, Sheffield, and G. C. Grant, Sheffield. Pouring or Teeming Molten Metals. (2 *Figs.*) November 13, 1917.—This invention relates to nozzles for pouring or teeming molten metals from ladles or receivers into ingot or other moulds. According to this invention, the nozzle of refractory material, which has a hole tapered, or otherwise formed, at the inlet end *a* and another hole at the outlet end *b*, which may be of smaller size, or of the same size, as the inlet, has, in the part between the inlet and outlet ends, a chamber or cavity *c* of larger cross-sectional area than the cross-sectional area of either the inlet or the outlet, in which



chamber or cavity the flow of metal regulates itself in passing through the nozzle and, on its exit from the nozzle, is reduced to a regular stream, free from splashing, or spraying, whatever may be the rate of flow. The nozzles can be made and provided with the chamber or cavity in any suitable way, such as in one piece by moulding, the chamber or cavity being formed in the course of manufacture whilst the refractory material is in a plastic condition, using, for example, a combustible core, which is burnt in the process of baking, or the nozzles may be made in parts, as in Fig. 2, capable of being connected together and adapted to fit into the ladle or receiver. (*Accepted November* 6, 1918.)

MOTOR ROAD VEHICLES.

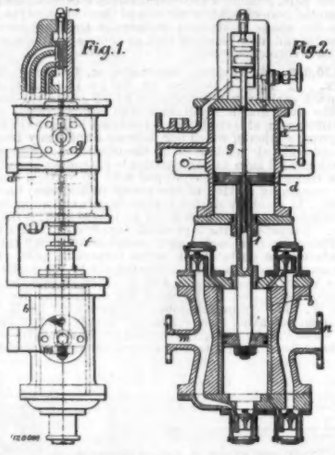
120,130. The Daimler Company, Limited, H. J. Balcombe, and T. Dawson, Coventry. Mechanically-Propelled Rail Vehicles. (5 *Figs.*) November 27, 1917.—This invention refers to the controlling mechanism for motor-driven vehicles in which a single hand lever is employed for operating the various gears and brake. The handle 1 of the controlling lever 2 is provided with a trigger 3 which must be gripped and retained in the position shown at Fig. 2 by the hand holding the handle of the lever 2, in order to render the lever operative for the control of the vehicle. A member 4 connected with the trigger 3 passes longitudinally through the lever 2. The rod 4, when the trigger 3 is held in the position at Fig. 2, is held against



the action of a spring 5, so that immediately the trigger 3 is released the rod 4 will descend and act upon a block 6 maintained in the position shown at Fig. 2 by a spring-impelled plunger 7. The block 6 carries an electric contact 8 which is held in sliding contact with an insulating plate 9 carried from the lever 2, and which insulating plate 9 carries two electric contacts 10, 11, the contact 10 being in circuit with an electric solenoid 13 controlling a valve 14 on a pneumatic brake system. When the electric contacts 8 and 10 are in contact, the valve 14 will be operated and the brakes applied. The contact 11 is in circuit with the magneto and when the electric contact 8 is brought into contact with the contact 11 the magneto is short-circuited and the engine driving the vehicle is stopped. (*Accepted November* 6, 1918.)

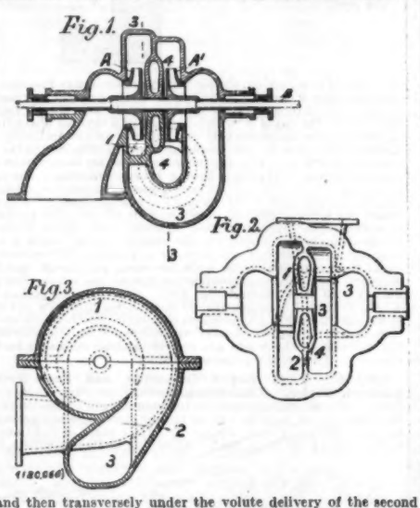
PUMPS.

120,091. T. Jefferson, Gateshead, and W. B. R. Vickers, Gateshead. Double-acting Steam Pumps. (3 *Figs.*) October 26, 1917.—This invention relates to double-acting steam pumps of that type in which the steam cylinder and pumping cylinder are arranged end to end with their axes in alignment, the steam and pumping cylinders being each provided with a piston, said pistons being fixed at the opposite end of a common piston rod which passes through suitable stuffing boxes in the adjacent ends of the cylinders, the steam and exhaust valve being disposed at the opposite end of the steam cylinder to the pumping cylinder and adapted to be operated by a "lost motion" connection to the piston of the steam cylinder. A pump of this type made in accordance with this invention is characterised in that the steam is admitted by a sliding D valve controlling three ports, the two outer ports of equal size leading to the top and bottom of the steam cylinder *a* respectively and the centre port leading to the exhaust, and in that the pumping cylinder *b* is tapered externally towards the centre. The "lost motion" connection whereby the slide valve is operated comprises a spindle *g* co-axial with the steam cylinder, connected at one end to the slide valve and extending through a gland into the steam cylinder and through an orifice in the centre of the steam piston *d* into the piston rod *f*, which is made hollow to receive it. The spindle *g* is provided with two stops or shoulders adapted to be engaged by a restricted orifice in a plate fixed on the piston *d* around the spindle, the arrangement being such that the moved slide valve



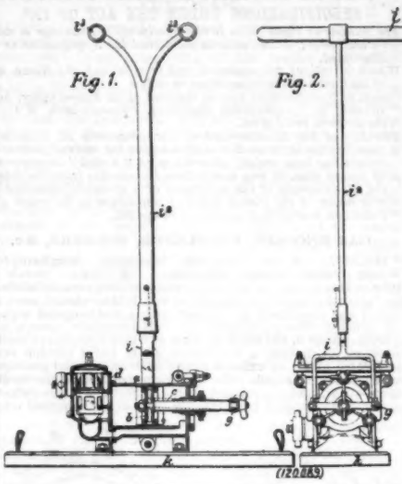
is thus moved only when the piston nears the end of its stroke. The pumping cylinder *b* is provided with separate inlet and discharge passages at each end. The two inlet passages lead in opposite directions from a common inlet orifice *m* to inlet chambers containing non-return valves which only permit inward flow, each valve chamber communicating with one end of the pumping cylinder. The two discharge passages lead in opposite directions to a common discharge orifice *n* from discharge valve chambers containing non-return valves which only permit outward flow, each valve chamber communicating with one end of the cylinder. (*Accepted November* 6, 1918.)

120,060. Worthington Pump Company, Limited, London. (*Worthington Pump and Machinery Corporation, New York, U.S.A.*) **Centrifugal Pumps.** (3 *Figs.*) September 17, 1917.—This invention relates to two-stage centrifugal pumps of the volute type having two single suction impellers back to back with their single suctions in opposite directions and with volute deliveries and a passage connecting the discharge volute of the first stage with the suction of the second stage. The invention consists in a centrifugal pump of the type referred to characterised by the discharge passage running tangentially from the first discharge volute in gradually increasing cross-section to gradually reduce the velocity of the fluid and transform it into pressure



and then transversely under the volute delivery of the second stage and upward to the eye of the second impeller. A, A1, are respectively the first and second-stage impellers carried by shaft B, these impellers being reversed so as to balance the pump. Delivery volute 1 from the first stage develops into a discharge passage 2 leading tangentially downward and gradually enlarging in cross-section, and continued by a cross passage 3 under the discharge volute 4 of the second stage and then curving upward to the eye of the second impeller. The volutes 1 and 4 are set about 50 deg. apart, which has been found to produce the smoothest and most efficient flow and to best provide for the suction and discharge connections from the lower section of the casing. (*Accepted November* 6, 1918.)

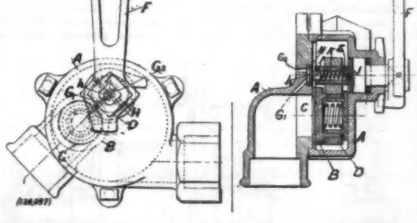
120,089. J. W. Restler, Westminster, London. Pumps. (4 *Figs.*) October 25, 1918.—This invention relates to pumps of the reciprocating type. The pump barrel *a* is fitted with a piston *b* operated by a rod *c* which, in the case of a double-acting pump, projects, at one end of the barrel, through a cover furnished with a stuffing-box. At the opposite end of the barrel is arranged a valve-box *d* formed in two compartments respectively communicating with the opposite ends of the barrel; the valve-box being provided with noxzles for the reception of the suction and delivery pipes. Each compartment of the valve-box *d* is provided with suction and delivery valves, preferably of the ball-type, arranged in a bi-part cage, the delivery valve seating being integral therewith, so that, by moving this part, the suction valve is rendered accessible. The noxzles are respectively common to both suction valve chambers and to both delivery valve chambers. The outer extremity of the piston rod *c* carries a crosshead *g*, to which are attached two return connecting rods or links arranged on either side of the pump barrel. These links are respectively connected to the two arms of a forked lever *i* pivoted below the centre line of the barrel. Above the point of



bifurcation, the lever is provided with a detachable extension i^2, whereof the upper extremity carries a cross-handle, or two cross handles i^3, i^3, according to whether it is intended to employ one or more operators. The entire apparatus is mounted upon a wooden or other foundation plate *k*. (*Accepted November* 6, 1918.)

RAILWAYS AND TRAMWAYS.

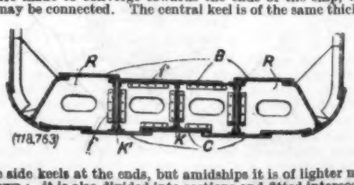
120,097. R. Sawyer, Worthing. Steam Heating Apparatus. (2 *Figs.*) October 27, 1917.—The invention relates to the operation of valves for steam-heating apparatus more particularly adapted for trains and is of the type in which the act of closing the main steam valve causes a flat subsidiary venting valve adapted to slide in the hollow spindle of the main valve to be rotated into a position in which ports are placed into communication so as to allow the escape of steam from the heating pipes to the atmosphere in order that the pipes can be uncoupled without risk of injury to the operators. According to the invention, the subsidiary valve is mounted in the spindle of a main steam valve formed as a circular slide valve rotating in its own plane. A is a casing in which a main steam valve B can be rotated in its own plane to open or close a port C admitting steam to the heating apparatus. The valve B is mounted



on an arm D of a spindle E which can be turned through an angle of 90 deg. by an operating handle F. Ports G1, G2, are provided in the casing A, and are placed in communication with one another by a recess A in a valve H when the handle F is operated to close the main steam valve B. The valve H is mounted on the spindle E, so that although it is constrained to move in its own plane when the spindle is rotated, it is free to move through a limited distance at right angles to that plane. For this purpose, the stem I of the valve H is inserted in an aperture K in the spindle E of the main valve and the cross-sections of the stem and of the aperture in which it slides are rectangular, or of other suitable form. The valve H is maintained in contact with its seating by a spring J inserted in the hollow spindle E. The valve B is also free to move through a limited distance to or from its seating against which it is pressed by a spring M. Stops N limit in either direction the movement of the handle F. (*Accepted November* 6, 1918.)

SHIPS AND NAUTICAL APPLIANCES.

118,763. S. S. Petersen, Hartlepool. Ships. (2 *Figs.*) December 19, 1917.—In a double-bottomed ship having a central keel K and a side keelson K1 on each side thereof, the side keelsons are made to converge towards the ends of the ship, where they may be connected. The central keel is of the same thickness



as the side keels at the ends, but amidships it is of lighter metal, as shown; it is also divided into sections and fitted intercostally between the floor plates R. The keels are secured to the inner and outer bottom B, C, and to the floor plates R by angle irons *f*, or by lugs or flanges formed integral with the keels. (*Accepted September* 18, 1918.